MINING engineering

NOVEMBER 1958

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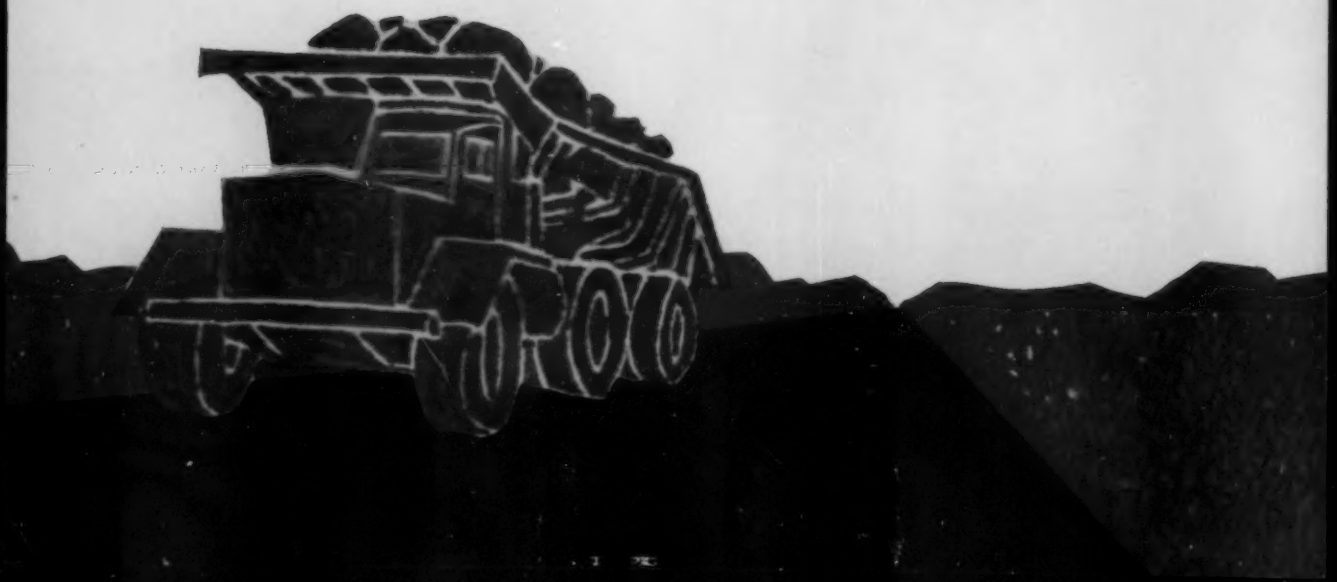

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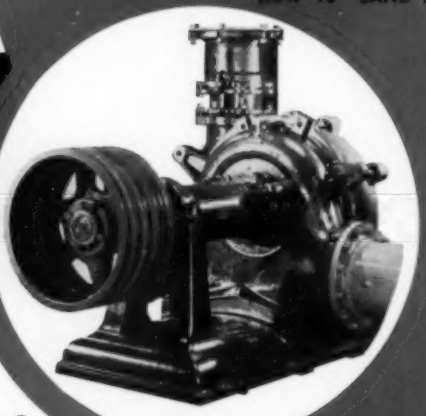

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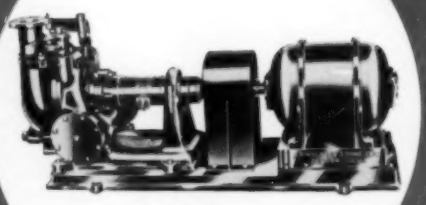

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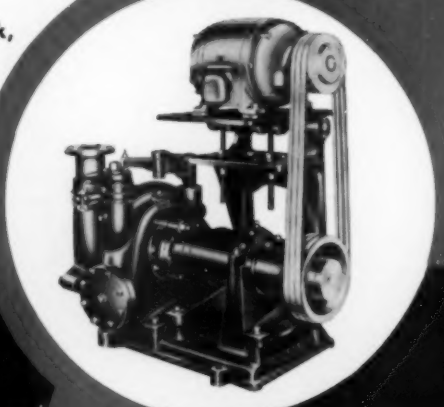

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COMING EVENTS

Oct. 31-Nov. 1, AIME Central Appalachian Section and West Virginia Coal Mining Inst., joint meeting, The Greenbrier, White Sulphur Springs, W. Va.

Oct. 30-Nov. 1, International Mining Days, New Mexico Mining Assn. and Southwest International Mining Assn., Carlsbad, N. M.

Nov. 5, AIME Chicago Section, Students Night; speaker: H. C. Rogers, Jr.; Chicago Bar Assn., Chicago.

Nov. 7, AIME Pittsburgh Section and AIME NOHC Pittsburgh Section, 13th annual Off-the-Record Meeting, Principal speaker: G. B. Warren, General Electric Co.; Penn-Sheraton Hotel, Pittsburgh.

Nov. 13-14, Missouri School of Mines and Metallurgy, 4th annual symposium on mining research, University of Missouri, Rolla, Mo.

Nov. 14-15, AIME Southeast Section, annual fall meeting, Atlanta.

Nov. 14, American Mining Congress, Coal Div. Conference, Penn-Sheraton Hotel, Pittsburgh.

Nov. 18, AIME Ohio Valley Subsection, President's night—guest: Augustus B. Kinzel; Ricardo's, Columbus, Ohio.

Nov. 20, AIME Utah Section, speaker: J. C. Strong; subject: Engineering Aspects of the Great Salt Lake Crossing Project; Salt Lake City.

Dec. 1, AIME Arizona Section, annual meeting, Pioneer Hotel, Tucson, Ariz.

Dec. 5, AIME Lehigh Valley Section, ladies' night, Speaker: Augustus B. Kinzel; Lehigh Valley Club, Allentown, Pa.

Dec. 6, AIME Eastern North Carolina Subsection, Southeast Section, Hotel Vance, Henderson, N. C.

Dec. 11, AIME Utah Section, panel discussion on Place of Research in the Minerals Industries; members: chairman J. M. Ehrhorn, S. R. Zimmerley, J. B. Clemmer, W. M. Fassell, Jr., J. R. Lewis; Salt Lake City.

Jan. 5-9, 1959, 2nd Caribbean Geological Conference, University of Puerto Rico and Economic Development Administration of the Commonwealth of Puerto Rico, sponsors; University of Puerto Rico, Mayaguez, P.R.

Jan. 12, AIME Minnesota Section, annual meeting, Duluth.

Jan. 13-14, Annual Mining Symposium, University of Minnesota, Duluth.

Jan. 15, AIME Utah Section, speaker: H. Wright; subject: Rubber and Plastic as Cost Savers in Metallurgical Installations; Salt Lake City.

Feb. 5-6, California Governor's Industrial Safety Conference, Biltmore Hotel, Los Angeles.

Feb. 5-7, Centennial Celebration and Mining Convention, sponsored by Colorado Mining Assn. and others, Denver.

Feb. 15-19, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

February, AIME Lima, Peru, Section, subject: panel review of Peruvian Geology, Lima, Peru.

Apr. 5-10, EJC 1959 Nuclear Congress, Public Auditorium, Cleveland.

Apr. 16-18, AIME Pacific Northwest Regional Conference, Olympic Hotel, Seattle.

Apr. 18, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

May 11-14, American Mining Congress, Coal Show, Cleveland.

Sept. 24-26, SME Industrial Minerals and Coal Divisions, joint meeting, Bedford Springs, Pa.

MINING engineering

Vol. 10 NO. 11 **NOVEMBER 1958**

COVER *Artist Herb McClure's road and truck on this month's cover illustrate the construction of high quality haulage roads to cut materials handling costs. Further details of such a method are given in the article on page 1167 of this issue.*

SOLVENT EXTRACTION

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1164 **Solvent Extraction at Gunnison, Colorado** • *H. L. Hazen*

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1169 **Lineament Tectonics and Some Ore Districts of the Southwest** • *E. B. Mayo*

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PERSONNEL

THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service, Inc (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 8c in stamps (no stamped envelopes) for forwarding and returning application. The applicant agrees, if placed in a position by means of the Personnel Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter or $12 a year.

MEN AVAILABLE

General Superintendent or Assistant Manager, E.M., in geological engineering, M.S. in geology, D.Sc. in mining, age 35. One and one half years exploration experience; one year as general mine foreman; six years as assistant mine superintendent (12,000-tpd underground operation). Presently employed in this position. Can speak Spanish. Author of several articles published in some mining journals. Excellent references. M-446.

Geologist, B.S. in mining geology, age 37. Nine years experience in exploration and development program for large open pit copper mines; experience includes ore reserve calculations, pit layout design, and field exploration; work involved mine examination and reports; knowledge of underground geology and engineering. Location, foreign. M-1916-San Francisco.

GEOLOGIST—excellent opportunity for experienced geologist to develop department of geologists, ore dressing technicians, surveyors, drillers, samplers, draftsmen, computers, and clerks—total of 60. Principal functions of department are:

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Geologist, B.S., age 27. Diversified experience in cement and uranium exploration as well as seismic surveys. Five years experience with light weight aggregates. Location, immaterial. M-447.

Graduate Mining Engineer, Canadian, age 33. Experienced in mine surveying, layouts, and dealing with contractor. Seeks more varied experience. Available on one month's notice. Location preferred, Canada or U. S. M-448.

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Mining Engineer, age 50, thoroughly experienced in efficient management of large mining and exploration enterprises at high level of responsibility, domestic and foreign. Presently employed as general manager of large South American mining property. Available 30 days. M-443.

Exploration and Mining Geologist, presently in Australia, offers knowledge and experience to companies or persons engaged in finding and/or minerals, especially under rugged conditions. Age 37, B.Sc. in geology, M.S. in economic geology; available immediately. M-444.

Mining Engineer, B.Sc. in mining engineering, age 29. Experienced in open pit and underground mining, research engineering, structural engineering, and cost estimating. Desire responsible position. Prefer Canada or northern U. S. M-445.

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Mining Engineer, B.S. in mining engineering, with major or minor in ore dressing, for combination field and laboratory process work with leading phosphate rock mining operation. Location, South. W5677.

Superintendent, Mining Engineer, for hard rock open pit, 25-man operation. Location, desert area, southern California. Salary, open. S3718.

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Mine Manager, lead, zinc, with training and experience to take charge of small Pb-Zn property and make it go. Old mine to be developed by American company. Must have Latin American experience and report single status to start. American mill superintendent and Mexican workers. Salary, about $9600 U.S. currency. Location, Sierra Madre Mountains, Mexico. S3843.

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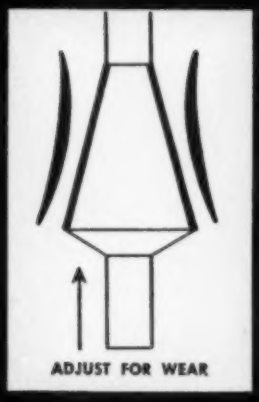
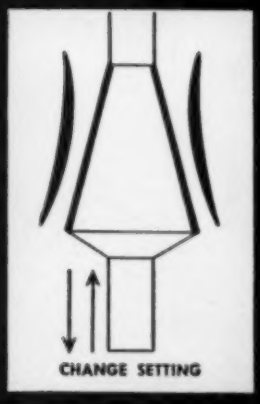
Mining Engineer, recent graduate, to be chief engineer at an underground copper mine. Location, South. W6510.

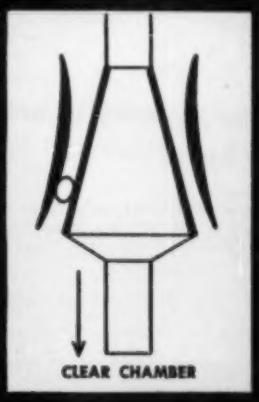
In Northern Manitoba, Sherritt Gordon Mines Limited, Mining & Milling Division, requires the services of a Mine Captain. Applicants must be graduate mining engineers with at least 5 years underground experience of which 3 should be as a Shifter. This position offers opportunity for advancement. Salary will be based on qualifications and experience. Housing, pension plan, group insurance, etc., available, if desired.

Application should be forwarded to Personnel Manager, Mine & Mill Division, Lynn Lake, Manitoba.

Superior crusher with Hydroset mechanism



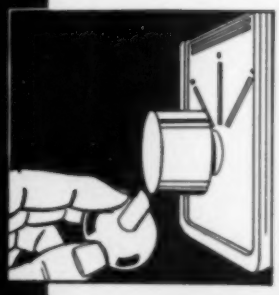




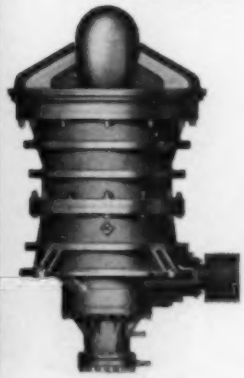
Plan to stay ahead... MODERNIZE!

Maintain circuit balance under varying operating conditions

The flexibility of a *Superior* primary or secondary crusher assures you maximum efficiency for the entire circuit under changing operating conditions. You can vary capacity by changing eccentric throw. You can change crusher settings in less than a minute. You maintain uniform product size easily over long runs — by simply flipping a switch to compensate for wear on mantle and concave. Result? Smooth flow of desired tonnage with minimum circuit adjustments — lower operating costs.



Flip the switch



The exclusive *Hydroset* mechanism in the *Superior* crusher raises or lowers mainshaft hydraulically, in less than a minute. This mechanism not only gives you "one-man, one-minute" product control but also helps clear the crushing chamber in case of power failure or other emergency conditions.

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- The Marcy principle of grinding..."rapid change of mill content is necessary for high efficiency," which is accomplished by the open end feature in Marcy Rod Mills.

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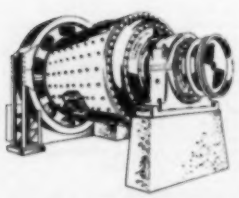
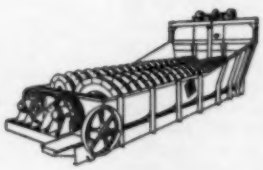
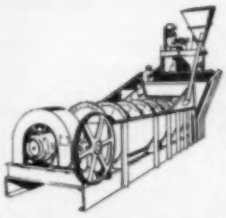


Marcy Grate Discharge Ball Mills



Akins Classifiers



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Geophysical Digest, issued quarterly by the *Central Board of Geophysics,* 5 Middleton St., Calcutta 16, India.—A review of progress and activities in a wide field including meteorology, hydrology, oceanography, seismology, volcanology, exploration geophysics, and radioactivity. This report is available on a subscription basis by writing to L. N. Kailasam, secretary of the Central Board of Geophysics.

Mining Year Book 1958, compiled by Walter E. Skinner, *Walter E. Skinner,* 20 Copthall Ave., London E.C.2, England, and *Financial Times,* 835 pp., $7, post free abroad, 1958.—Complete and up-to-date particulars of mining companies all over the world, including South African, Rhodesian, West African, Australasian, Far Eastern, American, Canadian, and foreign firms. Included are names and addresses of managers, professional services section, world production tables, and buyers' guide. • • •

Metal Statistics 1958, published by the *American Metal Market,* 18 Cliff St., New York 38, N. Y., 848 pp., $3.50, 1958.—*The little red book,* as it is known in the metals industries, contains over 400 statistical tables covering production, consumption, prices, and other data on ferrous and nonferrous metals. New tables added include world production of chromite and bauxite and shipments of aluminum foil in U. S. and imports from Canada. • • •

The Mining Journal, Annual Review 1958, *The Mining Journal Ltd.,* 15 Wilson St., Moorgate, London, E.C.2, England, 328 pp., 15s (approx. $2.15), 1958.—A review of metals and minerals includes nuclear, fuel, chemical, and metallurgical minerals; gems, and abrasives. An extensive survey of the world's mining fields covers the Soviet Union, West Africa, the Middle East, and other crucial areas.

Indian Mining Journal, Vol. V, ed. H. Ghosal, *Indian Mining Journal,* 6/2 Madan St., Calcutta 13, India, 394 pp., Rs. 15 (approx. $3.15), 1958.—This special issue on mineral beneficiation and extractive metallurgical techniques contains 52 papers by eminent Indian and foreign scientists that were contributed to a symposium in Jamshedpur in February 1957. Ore dressing and minerals beneficiation and hydrometallurgical upgrading of ores, thermal beneficiation, and extractive techniques based on chemical metallurgical methods are included.

Canadian Mines Handbook, 1958 edition, *Northern Miner Press Ltd.,* 116 Richmond St. W., Toronto, Ont., Canada, aprox. 300 pp., maps, $3.20, 1958.—The exclusive features of this edition include top producing mines classified as to metal, range of mining shares for the last eight years, plus all the information on the history, location, and profit and loss of over 8000 companies.

Coal Mine Directory, 1958 edition, *McGraw-Hill Publishing Co. Inc.,* $25, 1958.—This edition includes listings of all companies producing 50,000 tons plus cross listings showing changes in names and company affiliation since the last edition. A special feature is the geographical index showing the location of main offices. • • •

Coal Production in the U.S.A., by Companies, for the Year 1957, *McGraw-Hill Publishing Co. Inc.,* $5 or $2 for 10 or more, 1958.—Here is the complete picture of every company that produced 100,000 tons of coal in 1957. Comparison with previous editions shows the performance of each organization. • • •

Gmelin Handbook of Inorganic Chemistry, eighth edition, **System 45 (Germanium) Supplement,** *Walter J. Johnson Inc.,* 111 Fifth Ave., New York 3, N. Y., 576 pp., $79.68 unbound, $80.88 bound, 1958.—Bilingual English and German table of contents. This supplement to the 1931 germanium volume encompasses all the research up to 1953 since that volume. Technical preparation of germanium compounds is described in detail and several sections deal with varying aspects of the optical, electrical, and photoelectric properties. • • •

The Canadian Mineral Industry in 1957, *Dept. of Mines and Technical Surveys,* Mines Branch, Publications Distribution Office, Ottawa, Canada, gratis, 1958.—This report summarizes the developments in the Canadian mineral industry in three categories, metallic minerals, industrial minerals, and mineral fuels. Production, trade, and consumption of the minerals are outlined, along with occurrences and developments. In the first category such minerals are included as aluminum, antimony, bismuth, cadmium, chromite, and on down the alphabet to tungsten, uranium, and zinc. The second section covers abrasives, aggregates, arsenic trioxide down to silica, talc, and whiting. The mineral fuels covered are coal and coke, natural gas, peat, and petroleum.

Tatlock's Four Corners and Rocky Mountain Petroleum Directory, 1958-1959 edition, compiled by *Tatlock's,* 219 Majestic Bldg., Denver 2, Colo., $6.50, 1958.—Tatlock's oil and uranium directory lists more than 10,000 companies and their key personnel with a cross index of names and addresses and identification of top men in Federal, State, and Indian agencies.

Thirty-Seventh Annual Year Book for 1957 of the *American Bureau of Metal Statistics,* 50 Broadway, New York 4, N. Y., 136 pp., $4.50 hard cloth bound, $4.00 soft paper cover, 25¢ for postage outside of the U. S. and Canada, 1958.—An international survey sponsored by producers of copper, lead, and zinc which covers nonferrous mine production, smelter production, consumption, imports and exports, and other economic statistics. Monthly and annual tables of metal prices, lists of metallurgical plants, and other extensive data are included. • • •

State Publications

Soil Map of the Sussex Area, *State Bureau of Geology and Topography,* State Geologist, N. J. Dept. of Conservation and Economic Development, 520 E. State St., Trenton 25, N. J., 47x34 in., 50¢ (make check payable to Treasurer, State of New Jersey).

Photorelief Map for Illustrating Reports, *State Bureau of Geology and Topography,* State Geologist, N. J. Dept. of Conservation and Economic Development, 520 E. State St. Trenton 25, N. J., 10¢ each or $8.00 per 100 (make check payable to Treasurer, State of New Jersey).

Geology of Puertecito Quadrangle, Socorro County, New Mexico, Bulletin 41, by William H. Tonking, *New Mexico Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., 1957, $2.50.

Geology of Costilla and Latir Peak Quadrangles, Taos County, N. M. Bulletin 42, by Philip F. McKinlay, *New Mexico Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., $1.75, 1956.

Metal Mining Districts and Subdistricts, New Mexico, map, *New Mexico Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., $1, 1957.

Santa Fe, N. M., Guidebook, by Brewster Baldwin and Frank E. Kottlowski, *New Mexico Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., 25¢, 1955.

Taos-Red River-Eagle Nest, New Mexico, Circle Drive, Guidebook, by John H. Schilling, *New Mexico Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., 25¢, 1956.

Facts Concerning Uranium Exploration and Production, by John E. Crawford and James Paone, U.S. Bureau of Mines, *New Mexico Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., 70¢, 1956.

Uranium Occurrences in the Ambrosia Lake Area, McKinley County, New Mexico, by Robert G. Young and Gene K. Ealy, RME-86, U.S. Atomic Energy Commission, *New Mexico Bureau of Mines and Mineral Resources,* Campus Station, Socorro, N. M., 20¢, 1956.

The Origin of the Spinel-Emery Deposits with Particular Reference to Those of the Cortlandt Complex, New York, by G. M.

Friedman, Bulletin 351, *New York State Education Dept.*, N. Y. State Museum, Albany 1, N. Y., 68 pp., $1, 1956.

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Guide to Geology of John Boyd Thacher Park, by Winifred Goldring, Museum Handbook 14, *N. Y. State Education Dept.*, N. Y. State Museum, Albany 1, N. Y., 30¢.

Guide to Geology of Lake George Region, by D. H. Newland and Henry Vaughan, Museum Handbook 19, *N. Y. State Education Dept.*, N. Y. State Museum, Albany 1, N. Y., 90¢.

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IC 7831 Four Waterflooding Projects in Cowley County, Kans., 1958.

IC 7834 Engineering Control of Health and Safety Hazards in Uranium Mines.

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Alberta Coals and Automatic Domestic Stokers, Report No. 46, by Edgar Stansfield and Colin A. Genge, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 20¢ (in Canadian funds), 1945.

Soil Survey of the Grande Prairie and Sturgeon Lake Sheets, Report No. 74, by W. Odynsky, A. Wynnyk, and J. D. Newton, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 112 pp., 2 maps, 1956.

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Middle Albian Foraminifera from Athabasca and Peace River Drainage Areas of Western Canada, Report No. 75, by C. R. Steick, J. H. Wall, W. G. Bahan, and L. J. Martin, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 60 pp., 2 figs., 5 pls., $1.50 (in Canadian funds), 1956.

A Radiocarbon Date from Smoky Lake, Alberta, Preliminary Report No. 56-3, by C. P. Gravenor and B. Ellwood, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 17 pp., 1 fig., 25¢ (in Canadian funds), 1956.

Stream-Trench Systems in East Central Alberta, Preliminary Report No. 56-4, by C. P. Gravenor and L. A. Bayrock, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 11 pp., 1 fig., 2 photographs, $1 (in Canadian funds), 1956.

Glacial Geology, Sedgewick District, Preliminary Report No. 57-1, by C. P. Gravenor and R. B. Ellwood, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 43 pp., 2 maps, 50¢ (in Canadian funds), 1957.

Glacial Geology, Alliance-Brownfield District, Preliminary Report No. 57-2, by L. A. Bayrock, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 56 pp., 2 maps, 50¢ (in Canadian funds), 1958.

A General Outline of Groundwater Conditions in the Alberta Plains Region, Preliminary Report 58-1, by J. W. Foster and R. N. Farvolden, *Research Council of Alberta*, c/o Librarian, 87th Ave. and 114th St., Edmonton, Alberta, Canada, 46 pp., 4 figs., 50¢ (in Canadian funds), 1958.

Aerial Photographic Interpretation of Precambrian Structures North of Lake Athabasca, Bulletin No. 1, by J. D. Godfrey, *Research Council of Alberta*, 87th Ave. and 114 St., Edmonton, Alberta, Canada, 20 pp., 2 illus., 1 map, $1.50 (in Canadian funds), 1958.

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Mining Laws and Laws Related to the Mineral Industry, available from the office of the *Queen's Printer*, Victoria, B.C., Canada, upon payment of the price plus 5 pct tax: Dept. of Mines Act, 15¢; Mineral Act, 25¢; Placer-Mining Act, 25¢; Metalliferous Mines Regulations Act, 50¢; Coalmines regulation Act, 70¢; Mines Right-of-Way Act, 15¢; Iron Bounty Act, 15¢; Mineral Property Taxation Act, 15¢; Iron and Steel Bounties Act, 15¢; Indian Reserves Mineral Resources Act, 15¢; Prospectors' Grub-stake Act, 15¢; Taxation Act, 75¢; Forest Act, 80¢; Greater Vancouver Water District Act, 80¢; Security Frauds Prevention Act, 30¢; Coal Sales Act, 15¢; Coal Act, 25¢.

(Continued on page 1134)

LETTERS

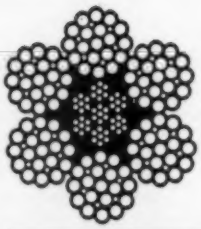
Needs of Deepest Mine

It now appears that the East Rand Proprietary Mines Ltd., a gold mining company of Rand Mines Ltd., is the deepest mine in the world with its H-winze which is 11,003 ft deep.

I am enclosing the following quotations from the Rand Daily Mail, Aug. 9, 1958, Johannesburg, South Africa:

> During the past 50 years the East Rand Proprietary Mine had milled 103,000,000 tons of rock and produced gold to the value of more than £312,000,000, said Mr. P. H. Anderson, chairman of the mine, at Boksburg yesterday at a ceremony marking the mine's achievement in reaching a world record depth of 11,000 feet. Mr. Anderson said that the mine's workings extended seven and a half miles along the 'strike' of the reef and three and a half miles along the 'dip.' Its property underlay 20 square miles of Germiston and Boksburg.
>
> "The mine has been the deepest for some time," he said. "It reached a vertical depth below surface of 11,000 feet on May 26. This is equivalent to more than two miles below the surface and a mile below sea-level. During the journey to the deepest working the rock temperature rises from 65 degrees to 123 degrees at 11,000 feet."
>
> Cooling plants, he said, were now a major feature of the mine's ventilation system. The surface and underground plants on the mine had a combined capacity of 3,500 tons of ice a day. Soon this would be increased to 4,300 tons a day. Its ventilation system circulated 2,000,000 cubic feet of air every minute, or 60 tons of air every minute. For every ton of ore hoisted, ten tons of air were sent down the mine, and 12,000 horse-power was consumed in supplying and cooling the air.
>
> "These achievements would not, however, have been possible had the richness of the ore body not persisted in depth. Gold mining operations, no matter how skillful technically, can be continued only as long as the value of the gold in the reef remains in excess of working costs, and working costs inevitably increase with depth," said Mr. Anderson.

Yours faithfully,
T. C. Brown



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This authoritative bulletin on cyanidation of precious metal ores, first issued in 1950, has been reprinted with an added section, Arsenic and Antimony Sulphide Minerals in Cyanidation. Check the table of contents below for a listing of the factual, useful information contained in this new issue of Mineral Dressing Notes. Send for your copy with the coupon below.

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ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

Solvent Extraction At Vitro by *W. B. Hall and Joy D. Lewis*—The Vitro milling operation and in detail the solvent extraction circuit are described. Some information relative to liquor preparation is also discussed. The presentation gives a brief picture of the Vitro operation and points out that solvent extraction is not without problems which require the careful surveillance and service of the metallurgical and chemical profession. **Ref.: MINING ENGINEERING, November 1958, pp. 1157-1160.**

Application of a Shrouded-Mixer Impeller for Solvent Extraction of Uranium by *L. D. Lash*—Acid leaching and counter-current decantation of hydrometallurgy are joined by liquid-liquid extraction to produce a refined product, in this case, uranium. The article gives a general description of one process for solvent extraction of uranium by an organo-phosphorus compound and then discusses some details of the mixing device used for the liquid-liquid contact. **Ref.: MINING ENGINEERING, November 1958. pp. 1161-1163.**

Solvent Extraction at Gunnison by *H. L. Hazen*—The uranium mill at Gunnison, Colo., started crushing ore Dec. 31, 1957, and had been operating four months at the time the paper was written. The acid leached ore is washed by counter-current decantation through a system of four classifiers and four thickeners and most of the dissolved uranium reports in the overflow from the first washing thickener. The solvent extraction section also demonstrates that CCD extracts 99.9 pct of uranium dissolved in acid solution, is easy to operate, and that chemical costs of recovering uranium from solution are competitive with other process costs. **Ref.: MINING ENGINEERING, November 1958, pp. 1164-1166.**

Asphalt Road Cuts Ore Haulage Costs by *Luther M. Krupp*—A 3½-mile asphalt mixed mat haulage road joins American Smelting & Refining Co.'s El Tiro copper pit northwest of Tucson and its Silver Bell mill. Two-axle trucks make frequent runs over the roadway but the asphalt top shows none of the *washboard* wear usually seen on dirt haulage roads during use by heavy vehicles. The data given cover construction of this road and results of its use by Asarco and Isbell Construction Co., the road's builder. **Ref.: MINING ENGINEERING, November 1958, pp. 1167-1168.**

Lineament Tectonics and Some Ore Districts of the Southwest by *Evans B. Mayo* (TP 4776I)—The objectives are to examine the structural framework of southwestern United States for evidence of the four principal directions, or trends, of lineament tectonics; to attempt a classification of their intersections; and to compare the positions of the most favorable-appearing ones with the positions of the ore districts. Insufficient data and the unavoidable personal equation make these objectives very difficult to attain. **Ref.: (MINING ENGINEERING, November 1958) AIME Trans., 1958, vol. 211, pp. 1169-1175.**

United States Government Support to the Mineral Industries of Latin America by *Sumner M. Anderson* (TP 4730A)—U.S. Government support of mineral industries in Latin America is presented as a practical basic element of the mutual security program, supplementing the principal support ably extended by American private industry. Activities through and since World War II are chronicled and to some extent evaluated. Banking and procurement on which investment returns are satisfactorily realized are conventional business supports on the billion-dollar scale. Technical assistance is a relatively new Government function impossible to measure precisely in long-term mutual benefits rather than the familiar standard of periodic dollar profits, but costing less than 3 pct of the banking and procurement investment in this field. This paper offers an answer to some criticisms of the support program in the mineral area. **Ref.: (MINING ENGINEERING, November 1958) AIME Trans., 1958, vol. 211, pp. 1176-1181.**

Scale-Up Relationships in Spodumene Flotation by *W. E. Horst* (TP 4779B)—The chemistry of spodumene flotation and quality of flotation feed was held constant for laboratory, pilot plant, and plant flotation tests to determine the relationship between flotation behavior and scale-up of flotation machine. Flotation rate constants and dimensional analysis were utilized to evaluate the scale-up relationships between laboratory, pilot plant, and plant flotation of spodumene. Additional retention time will be required in the plant flotation circuit to duplicate either laboratory or pilot plant results when the operating variables of the plant flotation machines remained unchanged. Actual plant performance with increased retention time substantiated predicted results. **Ref.: (MINING ENGINEERING, November 1958) AIME Trans., 1958, vol. 211, pp. 1182-1185.**

Rubeanic Acid Field Test for Copper in Soils and Sediments by *Harry V. Warren and Robert E. Delevault* (TP 4783L)—Soil testing is now a recognized prospecting tool. Normal soils usually contain 10 to 50 parts of copper in every million parts of soil. However, only 0.2 to 5 pct of this copper can be found by any simple cold chemical attack. Nevertheless, rubeanic acid makes it possible for a prospector, or field geologist, readily to detect as little as 4 ppm of available copper in a soil. This degree of sensitivity is adequate for determining the presence of copper anomalous areas and eventually discovering buried copper mineralization. **REF.: (MINING ENGINEERING, November 1958), AIME Trans., 1958, vol. 211, pp. 1186-1188.**

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Low Coke Button Bituminous Coal on Anthracite Equipment, by *J. Ludden and W. N. Sims*—Two years ago an investigation was begun on low coke bituminous coal for use at the Bound Brook, N. J., plant of American Cyanamid Co. as a replacement for anthracite. Since August 1957 the plant has been operating continuously on this coal with the exception of a new 200,000 lb per hr cyclone boiler.

This study was motivated not from a desire to conduct combustion research, but for the sole purpose of reducing steam costs. The indications were that the economics were greatly in favor of the use of the bituminous coal. The attempts to reduce the costs have developed some knowledge that has enabled this program to succeed reasonably well. *AIME-ASME Joint Solid Fuels Conference, October 1958*, 58SF5.

The Effect and Control of Impurities in the Electrowinning of Zinc, by *Guy T. Wever*—In the introduction the primary purpose of the process is discussed, and the main steps are outlined—mining concentrating of the ore, roasting the concentrate, leaching and purification, electrolysis of the purified solution, and casting zinc shapes for market.

The second part of the paper discusses the effect of impurities on electrolysis, with emphasis first on the elements normally found in zinc concentrates and in the electrolyte.

In the third section discussion of the control of impurities in the system is covered in four parts: the selection of the ore or concentrate; the roasting of zinc concentrates; leaching and purification; and control of the impurities during electrolysis. Occurrence of unusual amounts of impurities and the elements that may affect the process including concentrating the ore, are covered in the first part. Elements that may affect the roasting and that may be eliminated, are then discussed. Under purification, the separation of elements by solubility and in an iron purification, and in zinc dust purification are covered. Finally additive agents and cell conditions are weighed. *Rocky Mountain Minerals Conference, September 1958.*

Research in the Minerals Industry, by *B. D. Thomas*—Industrial research is in general directed toward the reduction of production costs or the extension of markets. In the minerals industry, research may be directed toward the improvement of prospecting methods, extractive operations, and materials processing to achieve the first goal; and toward the development of new uses of mineral products for the second.

This paper summarizes the position of the minerals industry in the industrial economy of the world, reviews the technical problems encountered, and indicates how some of these problems are being attacked by research. *Rocky Mountain Minerals Conference, September 1958.*

Tectonic History of the Basin and Range Province in Utah and Nevada, by *John C. Osmond*—North trending discontinuous ranges consisting of tilted fault-blocks with complicated internal structure are characteristic of the areas from the Wasatch Range to the Sierra Nevada. Generalized maps and cross sections illustrate the structural evolution.

Beginning in Cambrian time, the Codilleran geosyncline occupied the western margin of North America. The geosyncline was divided lengthwise into two parallel parts by a tectonic zone which trended north-northeast across Nevada from near Tenopah.

This zone separated shallow water carbonates on the east from deeper water clastics and volcanics on the west during the lower Paleozoic. The tectonic zone rose as an elongate welt in Mississippian time and expanded eastward and westward until by lower Tertiary time it included the former area of the geosyncline. Zones of subsidence flanking the welt also migrated laterally as it expanded.

Deformation occurred in various parts of the welt in each period since Devonian with

(Continued on page 1134)

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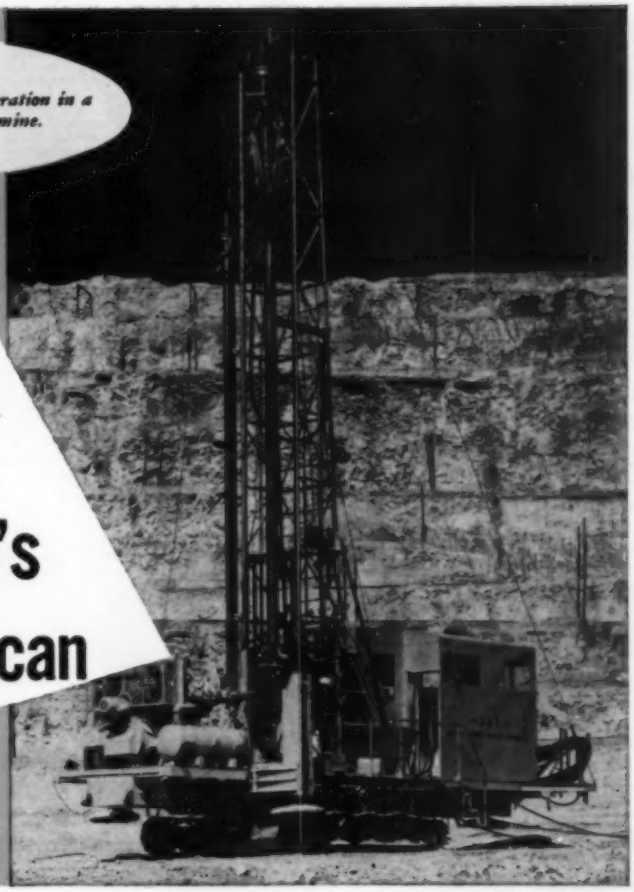

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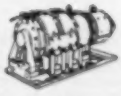

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ABSTRACTS

Continued from page 1132B

greater intensity in Mississippian, Jurassic-Cretaceous (Nevadan) and Cretaceous-Tertiary (Laramide). Widespread intrusion of granite stocks occurred in Cretaceous and Tertiary.

Toward the end of lower Tertiary the relief of the region had been reduced, and most of it was covered by a large volume of essentially horizontal volcanic extrusives. Following the extensive intrusion and extrusion the crust of the deflated welt adjusted by the movement along the pre-existing fractures, and the present ranges and valleys began to develop.

Movement along faults has continued since Miocene, and many of the valleys have been filled with over 5000 ft of tuffaceous clays and sands. *Rocky Mountain Minerals Conference, September 1958.*

Characteristics of the Oil Fields in Southeastern Paradox Basin, by *W. D. Quigley*—The area considered is located in San Juan County in southeastern Utah and includes the Aneth, Akah, Bluff, Boundary Butte, Cahone Mesa, Desert Creek, Gothic Mesa, Ismay, McElmo Creek, Recapture Creek, Ratherford, Turner Bluff, and White Mesa oil fields.

The Aneth field was discovered in February, 1956, by The Texas Co. and approximately 250 wells have been completed in the region since the discovery. A number of different but closely related oil fields have been found in the meantime. The initial production of the wells varies from 100 to well over 3500 barrels of oil per day. The area of intensive development now covers a 12-mile square area or 144 square miles.

Two main producing zones are present. Both are included in the Hermosa formation of Pennsylvania age and are approximately 5400 ft below the surface. They are called the Bluff and Desert Creek zones. The pay zones are composed primarily of fossiliferous limestones with shell fragments, coral, and calcarenite. The best zone is the Desert Creek zone, and a number of fields produce for both zones.

The reservoir in most of the fields is a combination of uplifted fractured limestone, shallow water limestone deposits, shell banks and calcarenite accumulations, and some patch reefs. The average thickness is between 40 and 80 ft. It is estimated that there could be over 100 million barrels of primary recoverable oil reserves in the Aneth field alone. The other fields together could possibly double these reserves. Exploration continues with high anticipation, making the petroleum future of Paradox Basin look very encouraging. *Rocky Mountain Minerals Conference, September 1958.*

Clays of the Intermountain Area—Uses, Markets, and Future, by *Charles A. Freeman*—General occurrence and distribution of fireclays in the Rocky Mountain area are discussed. The most important physical properties are pointed out. The effect of these properties on the refractory products are pointed out with reference to refractory service conditions.

The application of refractories produced in the area as they apply to Rocky Mountain industry is covered.

The future of the position of refractory manufacturers in the area is discussed with reference to probable industry requirements of the future. *Rocky Mountain Minerals Conference, September 1958.*

Trends in Mineral Engineering Education, by *John W. Vanderwilt*—The trend toward less emphasis on highly specialized and more on physical sciences and mathematics in engineering curricula has been increasing, particularly since World War II. Greater proficiency in the use of English is being stressed, and more courses in the humanities are being offered. Arguments are heard in favor of a broader education rather than over-specialization. On the whole, these trends are in the right direction. However, in the several fields of mineral engineering, industry interviewers still continue to seek out and favor graduates who have specialized.

It is estimated that the consumption of various metals, minerals, and fuels will increase by 50 to 150 pct in the next 25 years. The demand for mineral engineers will also increase, and greater competence, based on broader and deeper knowledge and understanding will be expected of men with graduate degrees.

The curriculum and teaching should be designed to best serve the student, the industry, and society. The graduate's immediate need is to make a living, so he must be able to put learning into practical use. But he should also have a breadth of knowledge and understanding that will enable him to live a full and productive life. Good mineral engineering education should meet these needs.

To achieve these goals, a flexible curricula is necessary. The satellites which mark the beginning of a space-missile age will serve to accelerate experimentation in engineering education. But a balance in courses is also essential.

A successful program requires more than a good curriculum. The student must cooperate, must want to learn, and the teacher must be able to instill this desire. The mineral engineer who expects to rise above the average will continue his self-education throughout his career. *Rocky Mountain Minerals Conference, September 1958.*

The Place of Automation in the Mineral Industry, by *J. E. Lawver*—The principal operational objectives of top management in a process industry are to scientifically determine the factors that influence profit, and to control these factors in order to obtain optimum profit.

Automation is one of the tools which makes it possible for top management to effect this end. Recording instrumentation provides the *tattle-tale* records necessary to scientifically determine the important factors associated with a process. The advent of high-speed electronic computers enables management to quickly and economically analyze even very complex plant data. The decisions by top management based on plant data analysis constitute an integral part of process automation. Once a mathematical model of a process has been formulated, optimum conditions can often be maintained automatically by modern instrumentation.

Automation in the mineral industry has steadily increased during the past decade but it has by no means reached its full potential value. Instrumentation such as that used in the iron and steel industry has become generally accepted as a necessary part of the process. Simple pH controls, flow controls, temperature controls, etc., are also widely used in all branches of the mineral industry. Some of the newer instruments that will soon be generally utilized include closed-circuit television and continuous quality control of products by use of X-ray fluorescence spectroscopy. *Rocky Mountain Minerals Conference, September 1958.*

Progress in Commercial Atomic Power, by *W. L. Budge*—Present costs and trends in costs in conventional power in the U.S. are covered according to regions and areas using available area cost figures. Conventional power costs outside the U.S. are then discussed.

Nuclear power cost consideration and trends are studied from three facets: 1) various plant concepts and evaluation are explained; 2) plant capital cost factors including safety, feasibility, location, etc., and 3) the plant operating factor, the core materials and core life are discussed considering processing and reprocessing costs.

The path to economic power is outlined in four stages. There are limitations on availability of fossil fuels and a need to conserve existing supplies. Research and development by industry and government should be expanded. Building and running prototype plants is a necessary process for operating experience and collecting cost data. Finally the future of breeder reactors and their importance as fissionable fuel conservation aid must be seriously considered. *Rocky Mountain Minerals Conference, September 1958.*

Innovations in Processing Nickel-Cobalt Ores, by *I. W. Nicholson, J. B. Clemmer, and P. T. Brooks*—The paper describes results of laboratory and pilot plant research undertaken for the General Services Administration to improve metallurgy of the U. S. Government-owned plant at Nicaro, Oriente Province, Cuba. Factors influencing the reductive roasting and oxidative leaching of laterite and serpentine ores for extraction and recovery of nickel and cobalt ore are discussed as related to operation of the Nicaro plant. The separation of nickel and cobalt from ammoniacal leach solutions by selective distillation, sulfide precipitation, and solvent extraction techniques are compared. *Rocky Mountain Minerals Conference, September 1958.*

The Use of Yieldable Steel Supports in Caved and Heavy Ground, by *James Quigley*—Steel supports rolled to varying weights and formed to arches of varying height and width are finding increasing application in western coal and metal mines for support of unstable rock. This paper describes a use of these arches at the Kaiser Steel Mine No. 3 at Sunnyside, Utah, and discusses other uses elsewhere in the west. At Sunnyside the arches are being used to reopen the lower workings of the No. 3 mine caved since the early twenties. Methods of piling and forepoling are discussed and rates of advance are given. The stability of the sections of the mine reopened by these methods is compared to similar sections of the mine reopened by cleaning up the caves and supporting the rock by roof bolts and landing mats and by reinforced concrete. *Rocky Mountain Minerals Conference, September 1958.*

Railroad Car Dumper Coal Sampling, by *W. R. Reichenstein and Armand Bur*—Coal is one of the largest cost items for the production of electrical energy. Its analysis for heat value and composition has been the subject of intensive study over the years. Sampling of coal started with crude hand sampling methods, out of the railroad car or barge, from moving conveyor discharge, and progressed to reliable mechanical in-plant sampling systems. The mechanical in-plant sampling system takes its sample from a falling stream of coal such as a conveyor discharge or crusher discharge hopper. The disadvantage of this system, however, is that the identity of the coal has been lost. Coal is shipped to the user in train-loads, and the train may be made up of coal shipments from various mines. Thus, when the cars are dumped into the hoppers and then conveyed to the station, the various shipments become mixed due to residual coal remaining in the hoppers and chutes.

The paper describes methods by which independent railroad car samples may be obtained. These methods, which adhere to ASTM accuracy, are outlined. *AIME-ASME Joint Solid Fuels Conference, October 1958,* **588F1.**

Fundamental Studies in Bulk Solid Flow, by *J. R. Lucas and W. J. Verner*—Internal vertical stress functions in bulk solid materials are put forth and evaluated. A new technique to indirectly determine these stress functions has been developed. A method is described which permits the evaluation of useful empirical coefficients for any bulk solid-bin material combination. *AIME-ASME Joint Solid Fuels Conference, October 1958,* **588F2.**

Dock Handling of Bulk Materials, by *R. C. Tench*—While ore tonnages handled at Newport News are not comparable to coal tonnage, the volume is steadily increasing and to take care of this business C&O has provided what is believed to be the world's most modern facility for transferring all types of ore from ships to railroad cars. This facility, placed in full operation in December 1957, is known as Ore Pier 9 and is capable of discharging the largest ore carriers now afloat as well as general cargo vessels of all types. Designed for maximum free digging capacity of 3,000 t an hour, records up to 3,000 t an hour have already been made and efficiency is steadily improving as operating personnel become more experienced.

This facility incorporates many of the best features of American designed ore unloaders, and also those of European design. European features are the slewing jib, the planetary winch for the hoist and closing lines, the joy stick control, the special trimming buckets with wide spans and low centers of gravity, welded construction, and the linkage which permits changing buckets in a few minutes without re-weaving of ropes. This is the first time these features have been used in America *AIME-ASME Joint Solid Fuels Conference, October 1958,* **588F4.**

BOOKS

Continued from page 1131

Vienne Area, Abitibi Territory and Abitibi-East electoral district, P. R. No. 337, by L. B. Gillett, *Dept. of Mines,* Hotel Du Government, Quebec, Canada, 1957.

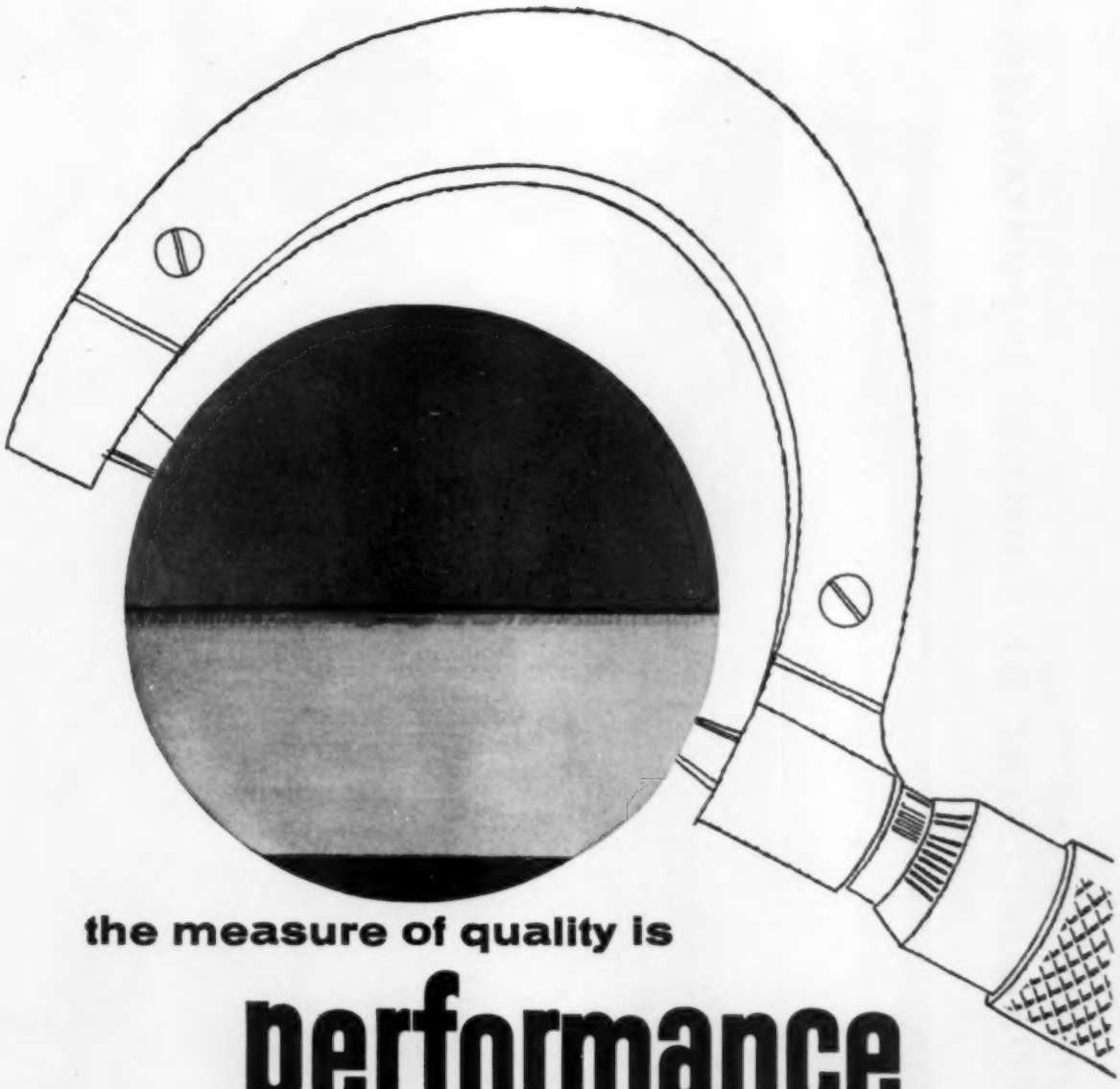
Litchfield-Huddersfield Area, Pontiac electoral district, P. R. No. 338, by Ralph Kretz, *Dept. of Mines,* Hotel Du Government, Quebec, Canada, 1957.

Ste-Felicite-Grosses Roches Area, Matane electoral district, P. R. No. 339, by Jacques Beland, *Dept. of Mines,* Hotel Du Government, Quebec, Canada, 1957.

Berand-Maserac Area, Rouyn-Noranda and Abitibi-East electoral districts, P. R. No. 340, by Peter V. Freeman, *Dept. of Mines,* Hotel Du Government, Quebec, Canada, 1957.

Dariens-Chabert Area, Rouyn-Noranda electoral district, P. R. No. 341, by Peter V. Freeman, *Dept. of Mines,* Hotel Du Government, Quebec, Canada, 1957.

Lake Bones Area, New Quebec, P. R. No. 342, by Jean Berard, *Dept. of Mines,* Hotel Du Government, Quebec, Canada, 1957.



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Moly-Cop Grinding Balls perform superbly on toughest grinding jobs because they have the necessary hardness to stand up to the long economical grind. They wear evenly because of that hardness which is uniform right to the core. That's the result of technological control in alloying, forging and heat treating by Sheffield. And the reason why Moly-Cop Balls are THE STANDARD OF COMPARISON AROUND THE WORLD.

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THE GISMO TRANSLOADER is a one-man operated SELF-LOADING and SELF-DUMPING TRANSPORT . . . a self-loading truck that shuttles back-and-forth between muck pile and dumping point without the synchronization of several pieces of equipment or positioning of equipment to load. It WORKS FULL SHIFT — loading, transporting and dumping in continuous, uninterrupted performance-cycles! It offers unusually low cost capital investment to do the job, as well as the lowest possible cost per ton for labor and maintenance. The Gismo Transloader is an advanced equipment development . . . the perfectly natural result of the performance of the Gismo powered by crawler-mounted tractors conceived a few years ago and doing an outstanding job in mechanized mining today! Write today for complete literature and information. *Manufactured by Sanford-Day Iron Works, Inc., Knoxville, Tenn.*

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- **S-D Mine Cars, all types and kinds**
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- **Tough, year-after-year wheel service by special S-D Hard Facing Process (this can really save you money and eliminated downtime)**
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- **S-D Gismo and S-D Gismo Transloader for mining, quarry and construction industries**

Gismo dipper actually digs-in below grade, at operator's option, to maintain level and cleaned-up haulageway regardless of bad condition.

This new high-speed, power-packed S-D GISMO TRANSLOADER is an entirely pneumatic-tired 4-wheel self-loading and self-dumping transport developed for long hauls, and featuring:

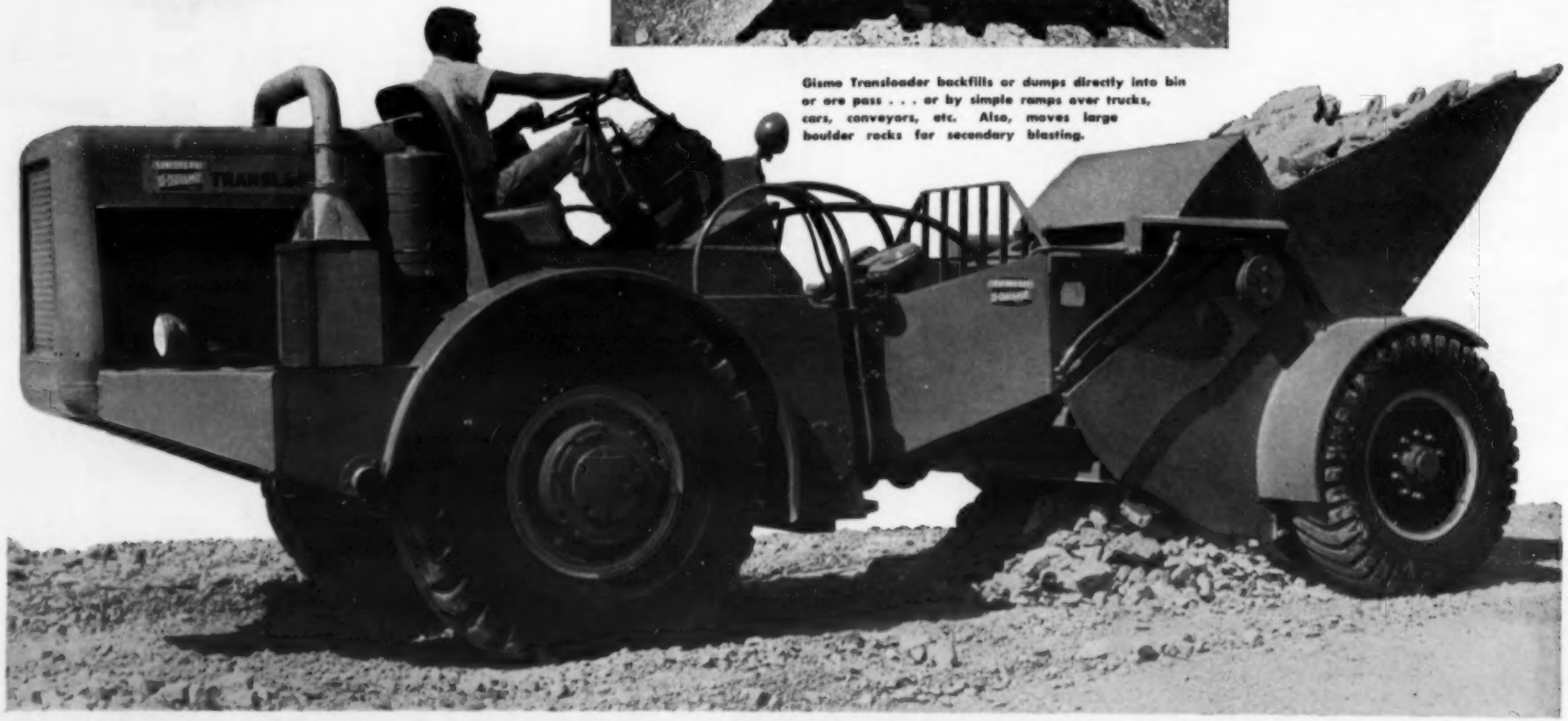
* HIGH SPEED TRANSPORTING . . . up to 20 miles per hour either direction—three speeds, forward or reverse with directional travel lever!

* NO TURNING or positioning for loading. Machine travels equally as well either direction!
* POSITIVE NO JACKKNIFING in mucking operation!
* POWER BRAKES . . . POWER STEERING . . . TORQUE CONVERTER!
* HAND-HANDY CONTROLS OPERATE DIPPER AND DUMP DOORS!
* PNEUMATIC TIRES to eliminate spring maintenance.
* OSCILLATING - COUPLING - UNIT ACTION and NO CONVENTIONAL STEERING MECHANISM usually associated with 4-wheel machines . . . therefore, less maintenance.

SANFORD-DAY

KNOXVILLE, TENNESSEE

Gismo Transloader backfills or dumps directly into bin or ore pass . . . or by simple ramps over trucks, cars, conveyors, etc. Also, moves large boulder rocks for secondary blasting.



1,000 Cu. Yd. per Hour Performance with 4 Cat Scraper-Tractor Combinations

Bucking weather and terrain, Cat DW20 Tractors with No. 456 Scrapers removed overburden on this uranium mining operation in Wyoming. The contractor used four DW20s to strip an average of 1,000 cu. yd. per hour.

W. N. McMurry, secretary-treasurer and co-owner of Rissler-McMurry of Casper, Wyoming: "I like the stability of the DW20!"

Mining uranium near Riverton, Wyoming, Rissler-McMurry used four Cat DW20s with matching No. 456 Scrapers to strip overburden at the lowest possible cost per cu. yd. This contractor, working for Vitro Minerals Corp., has utilized Caterpillar machines for 16 years. The owners like the stability, economy and power of their fast wheel scraper-tractor combinations for loading and hauling. They also relied on the rugged punch of a Cat D9 Tractor, a maneuverable D8 and a No. 12 Motor Grader to get the job done on schedule.

The DW20s excavated a 350,000 yd. pit—moving an average of 1,000 cu. yd./hr. Average depth of the pit was 66 ft., and material consisted of loosely consolidated sandstone and gravel plus cemented claystone in the pit's bottom. The DW20s handled a 600-ft. 10% ramp at one end of the pit with ease.

Now the new DW20 (Series F) rig is faster than ever and packs even more punch. Powered with a brand-new Caterpillar Engine, HP is increased to 320 (maximum output). At equal rimpulls, speeds are 10% greater. And torque rise is more than doubled compared to previous models. So the big wheel units give faster cycling for high production and wider profit margins. Combined with a Caterpillar LOWBOWL Scraper, the DW20 is the top earth-moving team for pit mining and other tough jobs.

For an on-the-job demonstration, get in touch with your nearby Caterpillar Dealer today. Find out for yourself if wheel tractors and scrapers can do your stripping more profitably than trucks and shovels.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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HAUL AT LOWEST COST PER CU. YD.

MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

R-N Process

A process by *R-N Corp.* permits treatment of iron ores to produce metallic iron briquettes, which may be fed directly to the electric, open hearth, or blast furnace. The process uses low cost fuels and is applicable to many ore types, both magnetic and nonmagnetic. **Circle No. 1.**

New Flocculant

Dow Chemical Co. has announced a new, high activity, polyacrylamide-type flocculant called Separan NP20. Dow labels it "the most active material available on a unit weight basis." **Circle No. 2.**

Lab Dry Separator

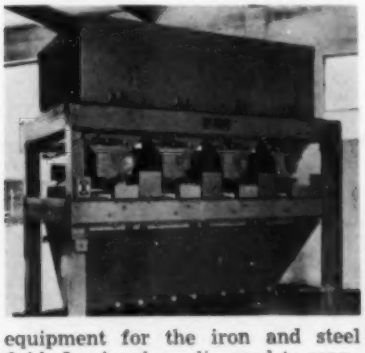
Sutton, Steele, & Steele Inc.'s technique of dry separation by fluidization is utilized in its new V-135 air-float table. Classification is made by particle size, shape, or specific gravity and unit is claimed capable of a continuous separation spectrum. Table weighs 225 lb, operates on ¾ hp. **Circle No. 3.**

Aerial Surveys

A helicopter electromagnetic surveying system licensed from American Metal Climax Inc. is being used by *Fairchild Aerial Surveys Inc.* for exploration service. Ask Fairchild for system data and results of test flights over known orebodies. **Circle No. 4.**

Joy Makes Separator

Joy Mfg. Co., biggest manufacturer of underground mining equipment, will begin producing beneficiation



equipment for the iron and steel field. Joy has been licensed to manufacture and sell to the iron ore industry the Carpco Research & Engineering Inc.-developed high tension separator (shown). Dry-operating unit is expected to be especially useful in Canada and other areas where climate problems curtail wet process operation. **Circle No. 5.**

Vibrating Screen

Allis-Chalmers has introduced the model SH Ripl-Flo, a totally enclosed, air-spring equipped screen. Quick opening latches permit easy access to all parts. An exhauster outlet can be provided in enclosure top if needed. **Circle No. 6.**

Improved Drillmaster

The well-known *Ingersoll-Rand* Drillmaster has been made more rugged by addition of a stronger mount. Unit, called TRUCM-3 puts its I-R Downhole drill into action in minutes. Carrier mounting meets legal requirements of all states, was designed by Crane Carrier Corp. on I-R specifications. **Circle No. 7.**

Pusher Leg Drill

Drifting, tunnelling, and stoping are all within working scope of *Atlas Copco's* new Tiger rock drill. The 60-lb, high speed drill has an integral pusher leg and is designed for holes up to 18 ft. More than 3000 short-stroke blows per min reduce recoil and assure special ease in collaring. **Circle No. 8.**

Waterproof Field Books

New waterproof field books, wet or dry, will allow use of the hardest pencil and are designed in a number of useful types by *J. L. Darling Corp.* The Rite in the Rain printed forms can be used in the worst weather conditions or underground and are available for mining transit, and other data. **Circle No. 9.**

Gismo Transloader

Sanford-Day Iron Works Inc. has developed a 4-wheel oreloader consisting of a large toothed dipper, intermediate fold-back mechanism with adjoining self-contained haul-

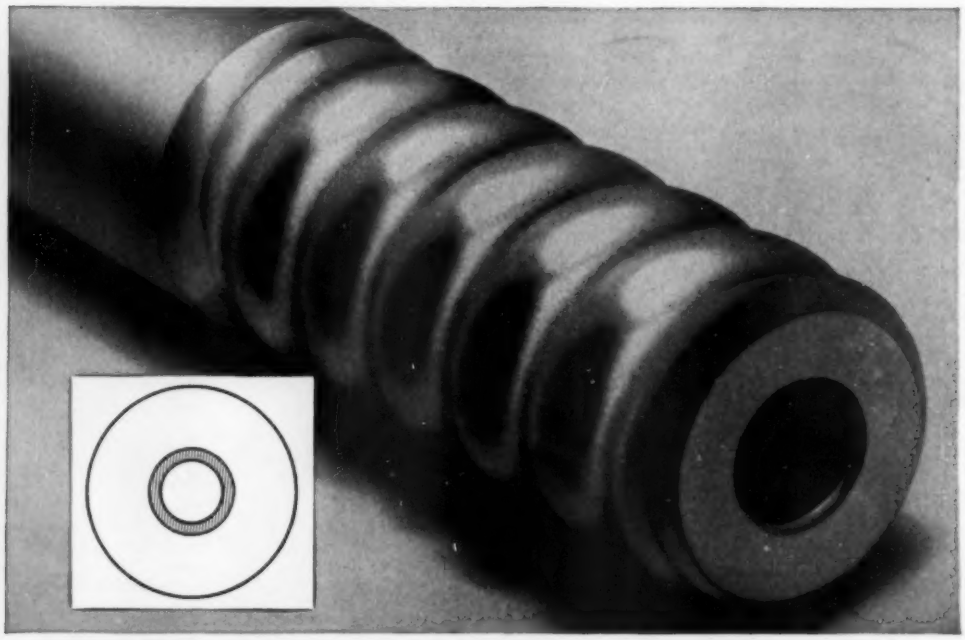
age body, and dump door. Dipper and fold-back action cascade material back into the Gismo until dipper is loaded. Machine then becomes a transporter with a payload of about 6 tons. **Circle No. 10.**

News & Notes

Hunting Assocs. Ltd. reports its Canadian unit Aeromagnetic Surveys Ltd. will now be called *Hunting Airborne Geophysics Ltd* . . . . A method of using hydrocarbons to produce sponge iron from iron ore has been developed by the Mexican steel producer *Hojalata Y Lamina S. A.* with engineering assistance of *M. W. Kellogg Co.* A subsidiary, Fierro Esponja S. A. of Monterrey, Mexico, has appointed Kellogg exclusive sales and licensing agent . . . . *American Cyanamid Co.* recently began full production at its new ammonium nitrate plant at New Castle, Pa. Facility is part of a building program which has increased Cyanamid's explosives output by about 60 pct . . . . *R. G. LeTourneau Inc.* has

unveiled its first piece of earthmoving equipment since 1953 (see above), calls it "the largest and most powerful earthmoving scraper ever marketed."

NEW ROPE THREAD MAKES UNCOUPLING EASY WITH SANDVIK COROMANT EXTENSION STEELS



Rope-Type Threads Afford No Starting Points for Fractures

Connections used in extension drill-steel must be easy to assemble and uncouple, and connections must not become weak links during the actual drilling. Sandvik Coromant's new patented rope thread makes it easy to join and uncouple the equipment . . . yet gives a solid and positive connection. The gently rounded form of this thread means trouble-free performance—eliminates common thread and coupling failures found in "saw-tooth" threads.

The complete equipment—bit, rod, coupling sleeve and shank adapter—are all dependable Sandvik Coromant parts made of world-renowned Sandvik alloy steel. A further advantage to the user is that the steel can be re-threaded. Atlas Copco has special literature on Sandvik Coromant extension steel and long-hole drilling, available to you with no obligation. We suggest you write today!

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Distributors of COMPRESSORS, ROCK DRILLS, PNEUMATIC EQUIPMENT, SANDVIK COROMANT DRILL STEEL and CARBIDE BITS

(21) CHEMISTRY OF CYANIDATION: No. 23 in *American Cyanamid Co.'s* well-known series "Mineral Dressing Notes" is a technical booklet of 54 pages detailing the chemistry of cyanidation in processing precious metal ores. Included is an analysis of the problems inherent in cyanidation of such ores, which also contain copper, zinc, nickel, arsenic and antimony, carbonaceous materials, sulfide minerals. Reagents used in flotation are discussed.

(22) RAKE CLASSIFIERS: *Morse* True-line rake classifiers and hydrosizers are illustrated in an 8-page brochure which describes their ability and performance under adverse conditions, emphasizing a minimum of maintenance and repair. *Morse Bros. Machinery Co.* advertises its hydrosizer for jobs where high grade fine mesh material and desliming is essential.

(23) ANGLEDOZERS: *J. I. Case Co.* has published an 8-page pamphlet to demonstrate by graph and illustration the power of their Case Terra-trac hydraulic Angledozers. Advanced features include big box-section blade that can be angled hydraulically from the operator's seat, torque-converter drive, power-shift transmission, and many other assets for maneuverability.

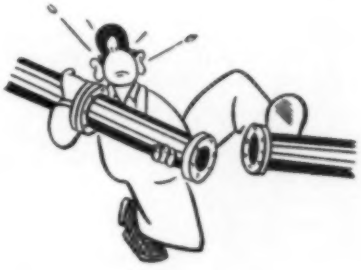
(24) DREDGE PUMP: *Thomas Foundries Inc.* offers a brochure on its Durable dredge pump an efficient unit of modern design. Thomas Ni-Hard is used in all parts subject to wear. A water jacket is provided between the shell liner and the outer casing to withstand shock and impact from heavy rock.

(25) INDUSTRIAL CRAWLER: *John Deere* industrial crawler 440 is dramatized in a data sheet featuring its modern styling, functional, rugged construction, and dependable power. The reverse side of the sheet lists specifications.

FREE LITERATURE

(26) MOBILE RADIO EQUIPMENT: *General Electric Co.* has prepared a 16-page booklet entitled "Under the Influence of Radio" to acquaint drivers with the benefits of two-way radio. Included is information on licenses for base stations, mobile units, instructions for adjustments, maintenance, and sending messages.

(27) FLEXIBLE PIPE JOINTS: *La Favorite Rubber Mfg. Co.* of Hawthorne, N. J., offers a series of four data sheets, containing specifications



and prices, on their vibration-absorbing, wire-reinforced neoprene pipe joints in both threaded and flanged types. Installation instructions include illustrated do's and don'ts.

(28) UTILITY TRACTORS: *Allis-Chalmers Mfg. Co.* presents its series D tractors in a bulletin describing low profile design and power features that include power-crater combustion, full pressure lubrication, and removable *wet* cylinder liners.

(29) WIRE ROPE BELT CONVEYOR: *Jeffrey Mfg. Co.'s* illustrated bulletin 948 describes advantages of its newest system of moving materials at low cost. Illustrations show types of carrying idlers, types of rope stands with return idlers, and installation views.

(30) ROTARY DRUM FILTER: *Dorr-Oliver Inc.* announces the availability of new 24-page bulletin 7200 describing five types of rotary drum units with 50 photographs and drawings of various filters and component parts, as well as tables of sizes and capacities.

(31) CABLE SPLICERS: *American Mine Door Co.'s* latest brochure illustrates the Canton cable splicers, binders, and terminals of fine quality brass and steel.

(32) INDUSTRIAL DESIGN: *Western Knapp Engineering Co.* has published a pamphlet called "Design for Progress," outlining its approach to design of modern industrial installations.

(33) TRACK SHOES: *Caterpillar Tractor Co.* gives a comprehensive discussion of track shoes and hardware in an 8-page booklet illustrated with photographs, drawings, and diagrams. Charts show optimum time at which grousers should be built up and torque specifications are listed for hardware.

(34) PROCESS EQUIPMENT: *Hardinge Co. Inc.* describes its complete line of process equipment for mining, chemical, stone, ceramics, water, sewage, and industrial waste applications in 8-page bulletin 100-B.

(35) VIBRATOR SCREENS: *Syntron Co.* has a catalog on vibrating screens and associated equipment. This 14-page booklet contains complete data and specifications for the line of nine standard models, with illustrations and typical installations.

mail this post card for more information

11

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after February 15, 1959—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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61	62	63	64						

Students should write direct to manufacturer.

(36) VIBRATING FEEDERS: *Syntron Co.* announces the publication of a 30-page catalog on their standard and special model electromagnetic vibrating feeders for hard-to-handle bulk materials. Complete descriptions, data, and specifications are included in the booklet.

(37) SELF-LOADING TRANSPORT: Gismo equipment by *Sanford-Day Iron Works Inc.* is highlighted in bulletin B100 which details a simple production plan for economy and maximum production. The self-loading transport is a ruggedly built mucking machine built to take punishment in rock excavation.

(38) LOADERS: *Myers-Whaley Co.* offers two bulletins on its Automat loading equipment, folder 6091 and catalog 250. The crawler unit operates without brakes or clutch. The shoveling machine loads coal, rock, and ore underground. Detailed information and photographs fill the catalog.

(39) DUST COLLECTOR: *Joy Mfg. Co.* has released a 12-page booklet outlining features of the Joy Microdyne dust collector. A wet inertial type collector installed as part of the duct, it offers a collection efficiency of 95 pct of all 5μ dust, 80 pct 1μ dust. Bulletin J-616 illustrates the collector.

(40) SPIRAXIAL COMPRESSORS: *Roots-Connersville Blower,* div. of Dresser Industries, Inc., presents design and construction data as an aid in selection of equipment for the process industries. Bulletin LAH 158 lists 17 sizes with ratings and capacities for each unit included in a selection table.

(41) CAP SCREWS: *Republic Steel Corp.* presents its bulletin of quality cap screws with fine or coarse threads to suit varying job requirements, emphasizing low cost, quick service, and prompt delivery.

(42) ALIPHATIC ORGANIC CHEMICALS: *Armour & Co.* through its Chemical Div. has published a new catalog of fatty acids and aliphatic organic compounds which lists products previously unavailable on a commercial scale, with revised specifications and recently developed applications.

(43) AIR COMPRESSORS: *Atlas Copco* offers a folder that shows how up to 60 pct of total power input can be reclaimed in useful form from its AR stationary air compressors. Power input is recovered in the form of hot water for washing, heating, and other industrial purposes at temperatures ranging from 120 to 180°F.

(44) TRUCK CRANE: *Baldwin-Lima-Hamilton Corp.* announces availability of a new 8-page catalog illustrating the Lima type 64-T, 50-ton capacity truck crane. Design and operating features are highlighted, including hydraulic power steering, rotating assembly, and independent planetary boom hoist.

(45) CEMENT PLANT: *Fuller Co.* has a 12-page bulletin discussing all phases of cement manufacturing at a new 200,000-ton plant in England. Bulletin ER-3241-1 gives full information on sizes and types of equipment.

(46) MOTORS: *Allis-Chalmers Mfg. Co.* offers a bulletin (05-51B9040) describing Super-Seal open-type motors suitable for many applications previously requiring enclosed designs.

(47) WELDING SUPPLIES: *Air Reduction Sales Co.'s* 52-page catalog of welding supplies and accessories covers their complete line of fluxes and ferrous and non-ferrous rods. Catalog 9-13 outlines electrode holders, sparklighters, cable, hose, weld cleaning tools, and other accessories.

(48) PROCESS EQUIPMENT: *Fuller Co.,* a subsidiary of General American Transportation Corp., describes equipment for the process industries in comprehensive bulletin G-3B. Applications and performance characteristics of Fuller-Kinyon pumps, Airveyor pneumatic conveyors, rotary compressors are discussed in detail.

(49) MAGNETIC EQUIPMENT: *Stearns Magnetic Products* summarizes its full range of products for protection against tramp iron and for purification and concentration of magnetically responsive materials.

(50) INDUSTRIAL TV EQUIPMENT: *Diamond Power Specialty Corp.* will supply bulletin 2239 describing major types of industrial television equipment, with five basic suggestions for equipment selection.

(51) BLOWERS: *Roots-Connersville* advertises a new compact design for R-C positive blowers in bulletin RAS-158. A vertical arrangement of the impellers to provide horizontal inlet and discharge connections results in substantial savings in floor space.

(52) GAS PUMPS: *Roots-Connersville Blower,* Div. of Dresser Industries Inc., publicizes its R-C type XA rotary positive gas pump, available in 18 sizes, in bulletin XA-458. A wide range of capacities, pressures, and drives in a simple design offers positive pumping and accurate volume. Technical rating data are clearly presented.

(53) TRACTOR DOZERS: *A Clark Equipment Co.* color catalog highlights design and operating features of 162-hp, 262-hp, and 375-hp rubber-tired Michigan tractors—models 180, 280, and 380. The dozer blade, no-spin differential, torque converter and power-shift transmission are also described.

(54) SHOVEL: *Manitowoc Engineering Corp.* has published a 12-page catalog of the 1½-yd model 2300 shovel, which is easily converted to 1½-yd clamshell or trench hoe, 1½ to 2½-yd dragline or 35-ton crane.

(55) GENERATOR: *Allis-Chalmers Mfg. Co.* highlights design, engineering, and construction of the G-226 portable, lightweight generator set in catalog BU-412. Sketches show in-use applications, engine cutaways, and photographs of numerous components.

(56) HEAVY DUTY POWER UNIT: *Willys Motors Inc.* has incorporated the Jeep 6-cyl engine in a power unit package enclosed in an easily accessible metal housing, with basic accessories and optional equipment. The engine features positive valve rotators, stellite valve inserts, 4-ring pistons, and heavy-duty bearings.

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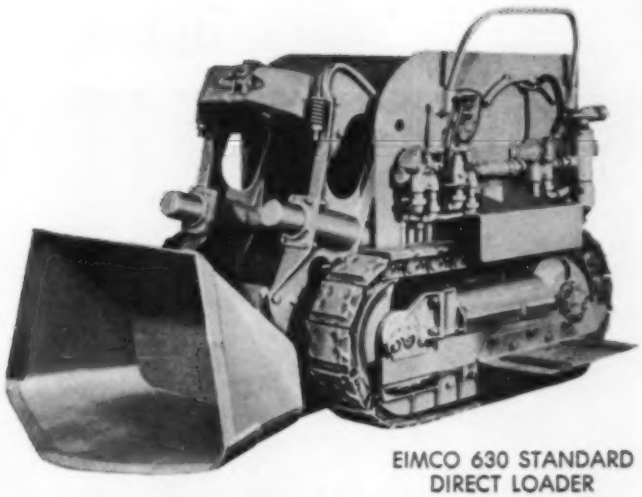

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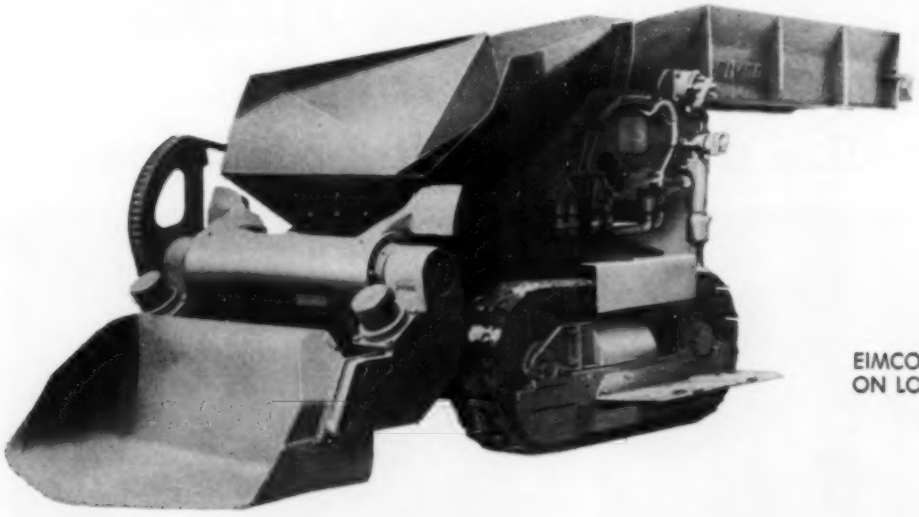

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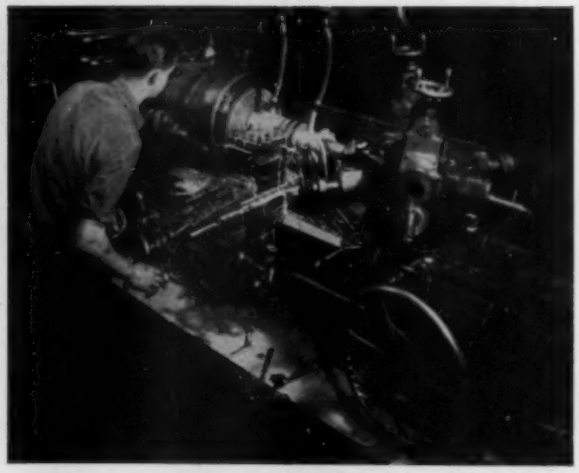

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INCO TRADE MARK

Lead-Zinc Import Quotas Announced, Prices Climb

Effective October 1, the Federal Government limited lead-zinc imports to 80 pct of the average annual commercial imports during the 1953 to 1957 period. Reactions among domestic producers were mixed, and mild. But there was no hesitation by foreign lead-zinc producers to condemn the block—outraged cries were heard around the world. In Peru the move was termed "economic aggression to our country." Canada called the quotas "basically contrary" to our mutual trade agreement. Australia officially protested, heard a minister say the cuts were of "tremendous consequence" to the Australian economy. Mexico leveled its blast with the cry that the step was "a mockery of the good-neighbor policy." Mexico acted almost immediately to prohibit all export of its lead and zinc materials pending study of the situation. Disruptions were expected widespread by countries that depend on the U. S. to absorb much of their production. Communist Czechoslavakia followed up the U. S. announcement with an offer to Peru, saying it would buy the lead and zinc Peru was unable to sell in the U. S. . . . . New York prices of both lead and zinc rose following the announcement, although the higher quotations were laid also to an increase in market strength. Lead had climbed 2¼¢ in about a month (2¢ since the announcement) to 13¢ and zinc had risen 1¢ to 11¢.

Mine Strikes Boost Copper Price

Labor disputes at key mines in Africa, Canada, and the U. S. have resulted in output decreases that pushed up the red metal's price. In the North Rhodesian Copperbelt, struck mines were Roan Antelope, Mufulira, N'Changa, N'Kana, and Chilbuluma. In Canada, International Nickel's Sudbury nickel-copper mines were closed over a dispute concerning a new wage contract, and in the U. S., Kennecott's Chino mine and Phelps Dodge's El Paso smelter were closed by a walkout. With pressure from consumption added, copper headed toward 30¢ per lb levels at month's end.

Silver Price Up Again

Producers of silver report sales at 90⅝¢ per doz. Since September 26 the metal's price had risen 1¾¢, due primarily to seasonal demand, industrial sales, and smaller supplies due to a slowdown in Mexican shipments caused by heavy rains.

Merger Trend Continues

Kennecott Copper Corp., through a new subsidiary, has acquired Okonite Co., a producer of insulated wire and cable. Okonite name will be retained . . . . Howe Sound Co. has purchased for cash Austenal Inc., maker of precision investment castings, dental specialties, and surgical appliances . . . . Stockholders have voted to merge Polaris Mining Co. into Hecla Mining Co. Hecla has also taken a 60-day option to buy 184,000 shares of Lucky Friday Silver-Lead Co.

NOTICE---SME PREPRINT AVAILABILITY

The following list of papers (from the 1958 New York Annual Meeting) will not be available after Jan. 1, 1959. Coupons received with the 1958 dues bills and those distributed at the 1958 Annual Meeting will also expire on this date. Purchased coupon books will be honored at any future date. A new listing of available papers will appear in a forthcoming issue. It will include papers presented at the 1959 Annual Meeting (San Francisco) and at other SME meetings throughout the year. Preprints may be obtained (upon presentation of properly filled out coupon) from SME Headquarters, 29 W. 39th St., New York 18, N. Y. Coupon books may be obtained from SME for $5 a book (10 coupons) for members or $10 a book for nonmembers. Each coupon entitles the purchaser to one preprint.

5817A1—The Pima Open Pit and Haulage Facilities by Robert Thurmond.
5817A2—Mining of Magnetite and Martite at Benson Mine by Arthur F. Peterson, Jr., and Wm. P. Bach.
5817A3—Estimating Data for Haulage Trucks —Open Pit Mines by Howard Wilmeth.
5817A4—Problems in Mechanization in Primitive Countries by James V. Thompson.
5817A6—Some Considerations in Determining the Origin of Ore Deposits of the Mississippi Valley Type by E. L. Ohle.
5817A9—Time Aspects of Geothermometry by R. J. P. Lyon.
5817A10—Ball Mill Performance at Super Critical Speeds by R. T. Hukki.
5817A11—A Study of Different Types of Steel for Grinding Media at Climax by F. Windolph and E. J. Duggan.
5817A12—Single-Stage vs Two-Stage Grinding at Homestake by C. E. Schmidt and F. M. Howell, Jr.
5817A13—Pebble Milling at Faraday Uranium Mines by R. J. Roach.
5817A13a—A Study of Grinding Ball Wear Employing Radioactive Tracers by A. L. Wesner, M. Pobereskin, and J. E. Campbell.
5817A18—Coal Mine Bumps Can be Eliminated by H. E. Mauck.
5817A20—Some Notes on the Principles of Mine Hydrology by H. E. LeGrand.
5817A23—Grouting and Water Control in the Kentucky-Illinois Fluorspar Area by H. C. Wrobbel.
5817P1—Preplanning Safety in the Uranium Mining Industry by John [illegible]ailey.
5817P2—Increased Safety, Better Production, Through Use of Communication and Electronic Equipment by A. [illegible]erry.
5817P3—Symposium on Safety and Health by James Wes[illegible] John A. Johnson, Herb N. Doyle, [illegible]es Romney.
5817P9—Relation of Magnetic Susceptibility to Composition in Sphalerite and Wurtzite of Wolfram[illegible]ite Group by E. [illegible] Spencer and [illegible] Mitchell.
5817P11—The Metallurgical Story [illegible]tion by C. B. Ketch[illegible] and K. L. Power.
5817P12—Collector Texture and Collector Frother Emulsions in Sulfide Flotation by Arvid E[illegible]erson.
5817P13—Coal Preparation at the Humphrey Mine by Victor Phillips.
5817P14—Application of Mineralogical Fundamentals to the Solution of the Coal Problem by M. [illegible]n and John Dasher.
5817P16—New Concepts in the Dependable Lifting of Bulk Solids by Bucket Elevator by C. R. Davis.
5817P17—Removal of Heat in Cement Grinding by J. R. Tonry.
5817P18—A Critical Study of Thickening by A. M. Gaudin, M. C. Fuerstenau, and [illegible] Mitchell.
5817P19—The Application of [illegible] for the Beneficiation of Sand and [illegible]el by John Meckenstock.
5817P20—The Application of Horizontal-Type Filters to the Metallurgical Industries by W. F. White.
5817P24—Economics Evaluation of an Industrial Mineral Project by J. E. Ca[illegible]
5817P25—Current Development in Gravel Beneficiation by W. L. Price.
5817P26—The Use of DSM Screens in a Heavy Media Cyclone Plant by W. R. Van Slyke, James Stukel, and L. D. Keller.
5817P27—Pima Mining Company Concentrator by G. A. Komadina and R. W. Herlund.
5818A1a—The Use of Ammonium Nitrate for Blasting at Mesabi Range Mines by Charles H. Grant.
5818A1b—The Use and Economy of Ammonium Nitrate Fertilizer Grade in the Open Pit Operations of the Anaconda Company in the Western United States and Mexico by A. C. Bigley.
5818A1c—Blasting with Ammonium Nitrate by Lewis J. Patterson.
5818A1d—Blasting with Prilled Ammonium Nitrate Fertilizer by W. M. Chapman.
5818A2a—Conveyor Belts at Miami Copper Co. by Benjamin R. Coil and James B. Fletcher.
5818A2b—Underground Conveyor Experience at Inland's Iron Mines by Howard M. Graff and James R. Gronseth.
5818A3—Raising by Use of a Cage by John C. Wangaard.
5818A4—Lac Tio Ilmenite Deposit by E. O. Dearden.
5818A5—The Titanium Sands of Southern New Jersey by Frank J. Markewicz, Daniel G. Parrillo, and Meredith E. Johnson.
5818A7—Sand Deposits of Titanium Minerals by J. L. Gillson.
5818A7a—Exploration Methods and Evaluation of Sand-Type Deposits by Frank McKinley.
5818A12—Effect of Soil Contam[illegible]on on Geochemical Prospecting in [illegible]eur d'Alene District, Idaho by [illegible]ney.
5818A13—Significance of Geochemical Distribution Trends in Soil[illegible] by [illegible]. H. [illegible]ardsey.
5818A15—Solubilit[illegible] of Sodium Ethyl Xanthates by [illegible] Wadsworth, [illegible]eteren and P. L. De[illegible]uyn.
5818A16—[illegible]ation and Reactivation Studies with Co[illegible]n Sphalerite by A. M. Gaudin, G. [illegible] and D. W. Fuerstenau.
5818A17—[illegible]culation of Contact Angle, Adsorption Density, Zeta Potential, and Flotation Rate by D. W. Fuerstenau and A. M. Gaudin.
5818A18—Experi[illegible]ith the FluoSolids Fine Coal [illegible] by W. Brandt.
5818A20—[illegible] Parameters by R. J. Lofquist and Jan[illegible] Wright.
5818[illegible]—[illegible]t of Iron Oxide Slime Coatings [illegible]on by A. M. Gaudin and [illegible]
5819A1—[illegible]me Legal Problems Encountered in [illegible] Acquisition of New Mineral Properties by R. E. Driscoll, Jr.
5819A3—Economics of Geologic Exploration by Donald M. Davidson.
5819A4—Valuation of a Mineral Deposit by A. L. Slaughter.
5819A5—Free World Demand and [illegible] Chrome Ore by J. M. Warde.
5819A6—Chemical Fuels and Other Non-metallic Compounds—Their Impact on the Mineral Industry by Donald Gibbons.
5819A7—Recent Developments in the Allowances for Depletion by Fra[illegible] H. Madison.
5819A8—[illegible] Future Ahead [illegible] Diversify Program by R. [illegible] Zuffelo.
5819[illegible]—Comparison of 2400 [illegible] Volt Distribution Systems for Coal [illegible]s by M. Wilson.
5819A10—Earthqu[illegible]ign for Metallurgical Plants by W[illegible]ster.
5819A11—[illegible]e[illegible]n at Affected by pH by [illegible]all.
5819[illegible]—[illegible]rs in the Selection of Motors and Speed Reducers for Conveyor Drives by [illegible]ark [illegible] Risler.
5819[illegible]—[illegible]oal Mine Personnel Selection by C[illegible]ailler.
5819A14—Meeting the Challenge of Mining in Thirty Degree Pitching Coal Seams by Albert M. Keenan and Andrew Allan.
5819A15—The Application of Industrial Engineering in Coal Mining by Charles W. Rountree, Jr.
5819A16—New Trends in Uranium Geology by Donald L. Everhart.
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5819P2—Dry Magnetic Cobbing Separations by Wm. M. Aubrey.
5819P3—Magnetic Separation in Beneficiation of Mesabi Range Magnetic Taconite by J. E. Forciea, L. G. Hendrickson, and O. E. Palasvirta.
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5819P8—A Comparison of Installation and Operating Costs of Automatic Skip Hoisting vs Belt Slope for Deep Coal Seams by R. R. Richart.
5819P9—Underground Movement and Subsidence Over the U. S. Potash Co. Mine, Div. of U. S. Borax and Chemical Corp. by E. H. Miller and F. L. Pierson.
5819P10—Boron—Its Past, Present, and Future by D. S. Dinsmoor and Frank Weishaupt.
5819P11—Uses of Standard. Ottawa Testing Sands by Paul A. Gerding.
5819P12—Utilization of Pennsylvania Slate for Expanded Aggregate by Frank D. Hoyt.
5819P15—Jackling Lecture—Planning Deep Mining at Homestake by A. H. Shoemaker.
5820A2—Statistical Method of Calculating and Analyzing Ore Reserves by John A. Patterson.
5820A4—Fundamental Studies of Percussion Drilling by Howard L. Hartman.
5820A6—Rapid Field Methods for the Colorimetric Determination of Nickel for Use in Geochemical Prospecting by Harold Bloom.
5820A8—A Nuclear Detector for Beryllium Minerals by T. Cantwell, N. C. Rasmussen, and H. E. Hawkes.
5820A11—FluoSolids Roasting of Sulfides for Recovery of Copper, Iron, and Sulfur by H. Kurushima and R. M. Fo[illegible]y.
5820A12—Beneficiation of [illegible] Iron Ores Involving Dir[illegible]ion [illegible] Alex Stewart and H. K[illegible]
5820A13—Reduct[illegible]-Grade Port Henry Ma[illegible] Co[illegible]ntrated by Earle C. Smith and D. E[illegible]ak.
5820A14—Recovery of Iron Ores Containing Titanium, Manganese, Chromium, and Alumina as Metal Sulfates by A. G. Oppegaard, Sokkiebush, and G. G. Reed, Jr.
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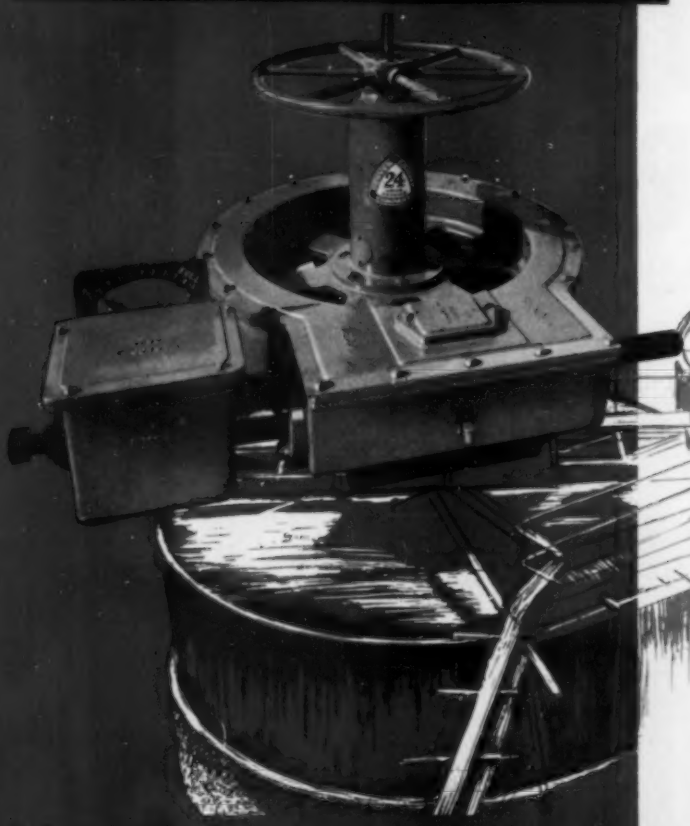

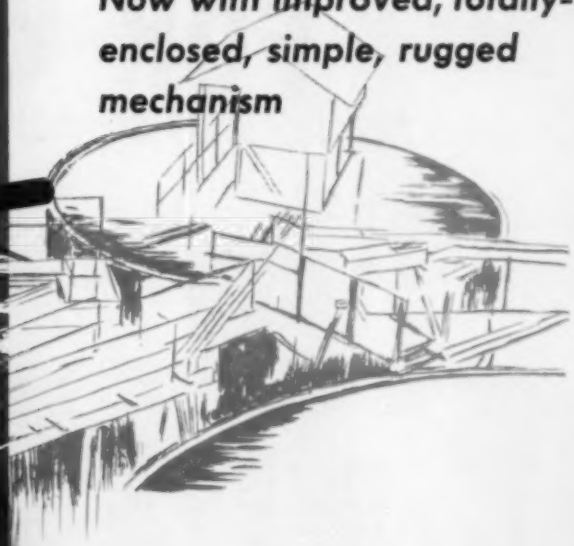

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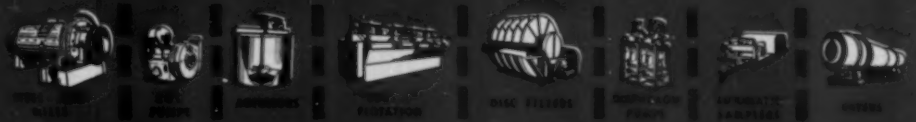

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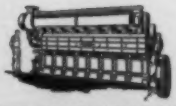

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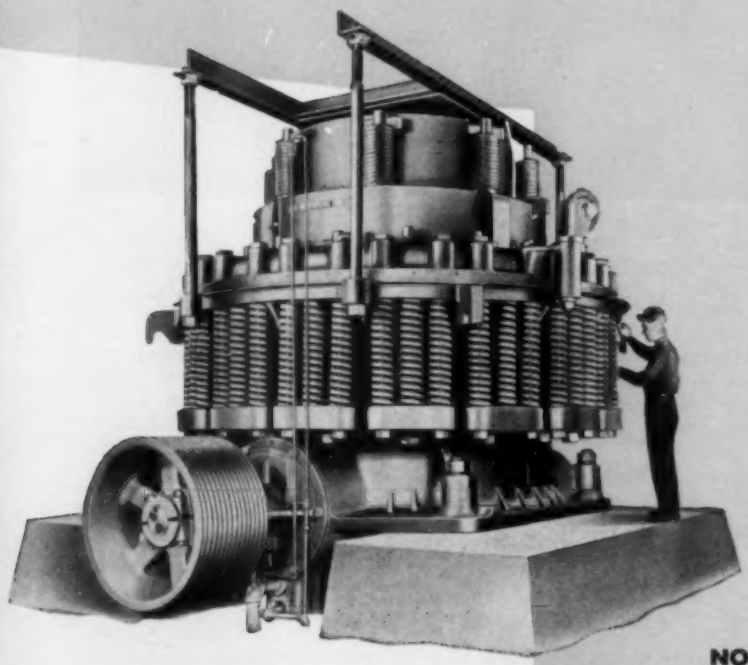

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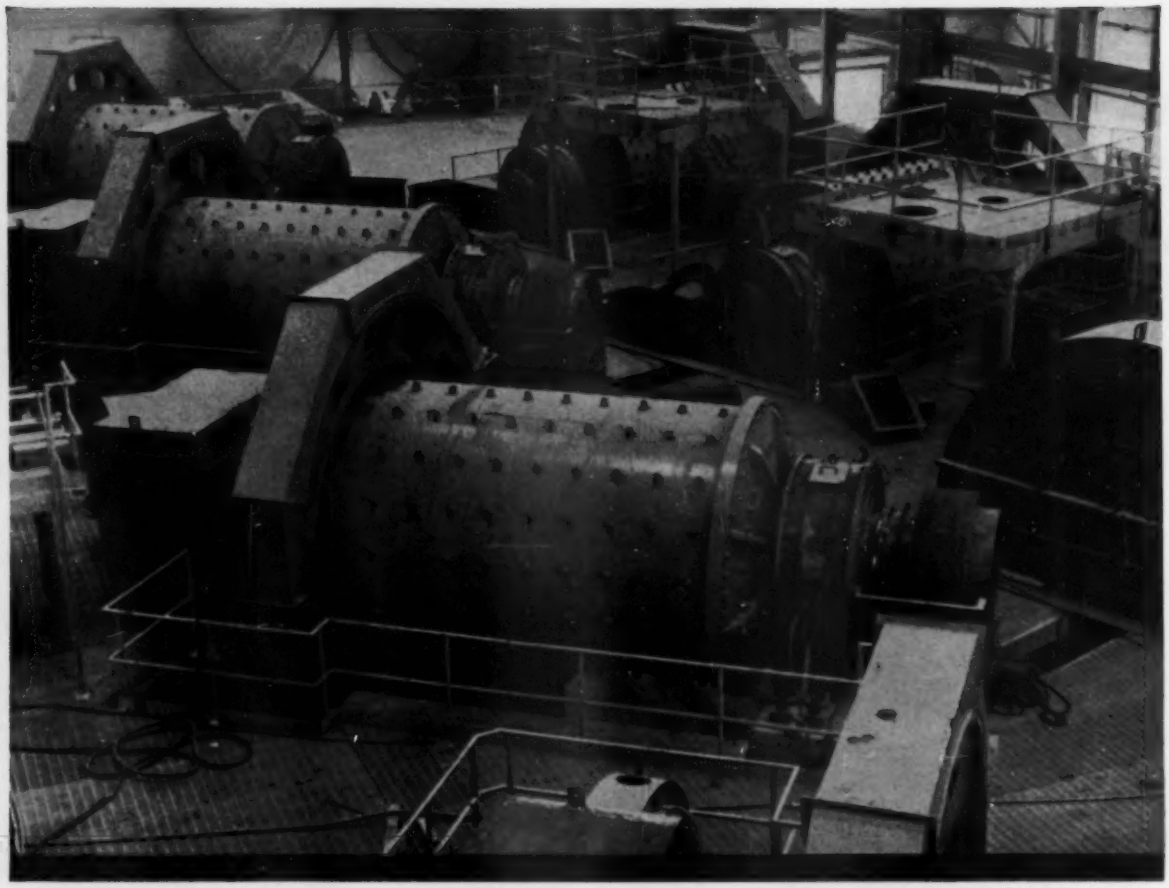


for tough grinding problems KENNEDY Ball and Rod Mills

KENNEDY Ball and Rod Mills solve the toughest grinding problems by providing dependable wet or dry grinding at low cost and with minimum maintenance. Consult KENNEDY and learn more about these features that distinguish KENNEDY Grinding Mills:

- Cast steel or Meehanite heads
- Welded and stress-relieved heavy steel plate shells
- Large diameter trunnions
- Self-aligning bearings with adjustable sole plates
- Positive "Ferris Wheel" lubrication of main bearings
- Oil-tight bearing seals
- Motorized hydraulic lift to reduce starting torque
- Single helical cast steel gear and pinion

KENNEDY VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

405 PARK AVENUE, NEW YORK 22, N.Y. • FACTORY: DANVILLE, PA.

Primary & Secondary Gyratory Crushers • Jaw Crushers • Roll Crushers • Impact Breakers • Hammer Mills • Rod & Ball Mills • Kilns Dryers • Screens • Conveyors • Complete Crushing, Lime and Cement Plants. KENNEDY Research & Testing Services.

Announce Engineering Firm

It is not often that a firm starts out with a billion dollars in past experience and $150 million worth of business on the books, but that is the story of Anaconda-Jurden Associates Inc., newly formed Anaconda subsidiary. The organization, formerly the engineering department of the parent company, is offering a complete planning, design, engineering, and construction service for industrial plants of major size.

"Working with outside concerns is not a new experience for us," Wilbur Jurden, president and chief engineer of the new firm, explained. "For many years we have had the experience of serving Phelps Dodge in providing engineering services for several of their key installations, including the Morenci, Ariz., reduction works. For the Erie Mining Co. we have successfully brought into production a commercial taconite plant and the required accompanying power plant. Our engineers turned out more than 6300 design drawings in the course of engineering the Erie project."

The Anaconda Co. engineering department, now incorporated as Anaconda-Jurden Associates, had its origin some 50 years ago when Marcus Daly commissioned E. Klepetko to design and construct what is now the Washoe Reduction Works at Anaconda, Mont. Based in Montana the department grew and strengthened over the years until in 1930 the company's foreign work and jobs in the East necessitated establishment of a central engineering office in New York.

Until 1939 efforts were devoted entirely to the requirements of the parent company and its subsidiaries. At that time the department undertook the Morenci project at the invitation of Phelps Dodge. Many other projects both within and without the company have followed. In a preface to the announcement Anaconda board chairman Clyde E. Weed, pointed out that it had taken more than two decades to assemble "this group of unexcelled technicians into an integrated engineering and design organization qualified to handle the planning, designing, and engineering of industrial plants."

Mr. Weed recently said that, "For 50 years we were known as Anaconda *Copper Mining* Co. Three years ago it was decided to drop the two words, "Copper" and "Mining" from the corporate title simply because they were no longer descriptive of the scope of our activities. Today Anaconda not only mines copper and other metals, but it also produces aluminum pig, uranium oxide, and manufactures and treats and prepares most of these metals for marketing." He might add now that they also "market plants."

Philippines Liberalize Legislation

The Philippine Congress has amended the so-called Nickel Act in an effort to encourage foreign mining companies to seek a concession for the exploitation of the Suriago laterite deposits along the north coast of Mindanao. The government plans to ask bids for the concession.

American technicians of the International Cooperation Administration have worked for several years with the Philippine Bureau of Mines in a program of exploration and metallurgical research on the Suriago deposits. Large ore reserves have been disclosed and treatment processes for the recovery of the metals have been tested successfully.

Exploration of Area No. II of the Suriago Mineral Reservation has disclosed laterite deposits of 129,900,000 metric tons containing 46.71 pct Fe and 0.93 pct of Ni. The same area has serpentine ore deposits of 13,020,000 metric tons containing 14.91 pct Fe and 1.70 pct Ni. The laterite, averaging 7 meter thickness, covers an area of about 2,500 hectares. Recoverable iron (as steel), nickel and cobalt are estimated to have a gross value at present American prices of $6 billion.

The U. S. Bureau of Mines has made continuous electric smelting tests on samples of the ore sent to this country. These tests resulted in recovery of approximately 90 pct of the nickel, 75 pct of the cobalt, and 80 pct of the iron. The iron was recovered in the form of a mild steel that contained less than maximum allowable nickel and chromium.

Coal is available for smelting operations in the area and an ample potential for the generation of hydro-electric power is available at Iligan City, which is 158 miles to the southwest of Nonoc Island, one of the main ore deposits.

The Philippine Bureau of Mines has estimated capital investment of about $50 million, of which one-half would be in local currency, would be required for a combined nickel-steel project to treat 2,000 tpd of ore. It is estimated this amount of ore would produce about 210,000 tons of mild steel a year, which is just about the present annual steel requirements of the Philippines. This would represent about 60 pct of total production.

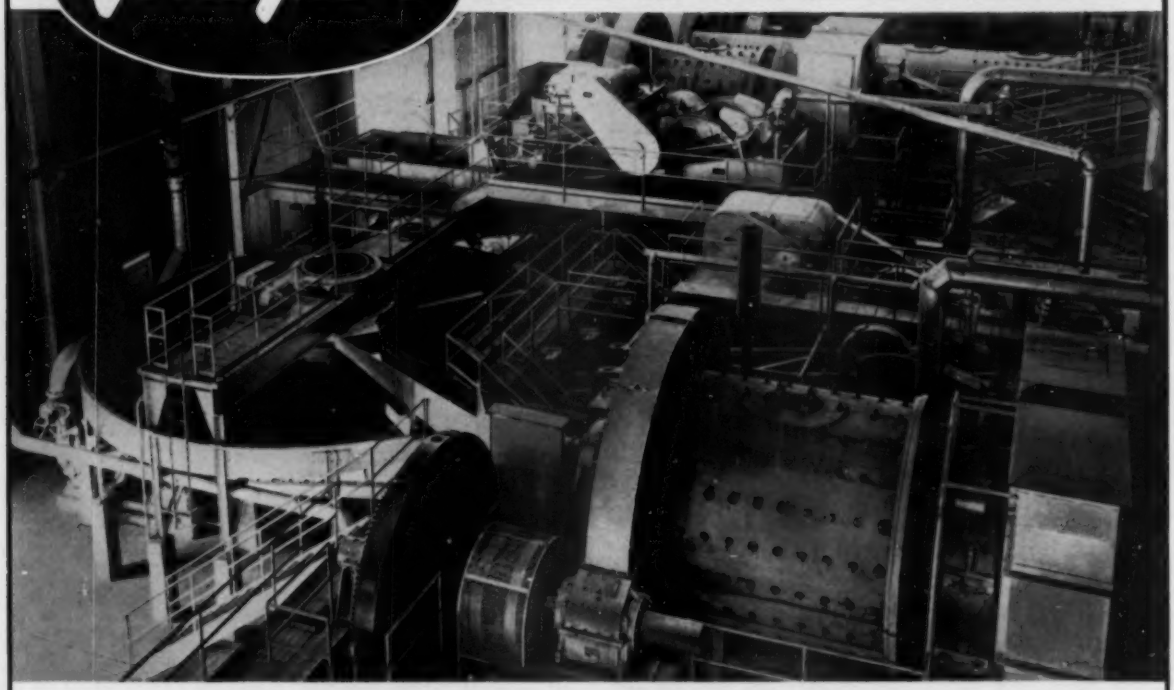
The Philippine Bureau of Mines is publishing a detailed report on the Suriago deposits which will be available late in October.

Department of Special Problems:

The following notice appears in a recent publication by the Ghana Geological Survey: *A poisonous insecticidal solution has been used in binding this book.* (Heretofore we have only found such solutions between the lines.)

DEPENDABLE

Traylor-MADE BALL MILLS



Traylor Ball Mills are made in two general types—overflow and diaphragm discharge. They are designed and built to be used for either wet or dry grinding. Shells are of all welded steel construction. The trunnions are cast integrally with the detachable heads. Main bearings are made of Meehanite* metal, each fitted with a high pressure Alemite pump.

Driving gears are steel, precision cut on our Maag gear generator. Mills may be fitted with drum feeders, scoop feeders or a combination of the two.

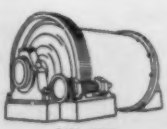
Traylor-made Grinding Mills can be made in any size to meet any requirements. Write for bulletin No. 11-121 for information on Ball, Rod, Compartment and Tube Mills.

TRAYLOR ENGINEERING & MFG. CO.

2003 MILL ST., ALLENTOWN, PA.

Sales Offices: New York — Chicago — San Francisco

Canadian Mfr.: Canadian Vickers, Ltd., Montreal, P.Q.



BALL MILLS

ROTARY KILNS

APRON FEEDERS

PRIMARY GYRATORY CRUSHERS

JAW CRUSHERS

SECONDARY GYRATORY CRUSHERS

CF&I Expansion Type Rock Bolt—with Pattin Type D-1 expansion shell . . . for 1⅜" holes . . . with right or left hand threads (to allow tightening by left-hand rotation of drilling machines). Also available, the Pattin D-5 shell for use with ¾" and ⅞" bolts in holes of 1⅝" diameter . . . and CF&I Slot-And-Wedge Type Rock Bolts.

stronger, safer, space-saving support... AT LESS COST

strength—when anchored in mine roofs or walls, CF&I Rock Bolts provide maximum resistance to load with a minimum of displacement. Pattin expansion shells double the usual shell expansion, grip twice as hard.

safety—high strength steel, (to American Standard Specifications for Roof Bolting Materials sponsored by American Mining Congress), provides ample factor of safety...fully safety-tested...proven in use throughout widespread applications...CF&I Rock Bolts eliminate the danger of timbers bending or buckling under load.

space-saving—cumbersome, space-consuming timbering methods may be unnecessary. CF&I Rock Bolts permit maximum utilization of available work space and ventilation facilities.

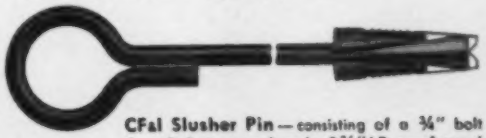
cost-saving—less bulky, easier to haul and install than heavy timbers. When used with Realock Metallic Fabric for lagging, CF&I Rock Bolts offer proved initial-cost savings up to 35% over timber sets.

OTHER CF&I PRODUCTS FOR THE MINING INDUSTRY

CF&I Grinding Balls • CF&I Grinding Rods • Wickwire Rope • Mine Rail and Accessories • CF&I Industrial Screens • Realock Metallic Fabric

***ALSO,* for your convenience,**
CF&I SLUSHER PINS

When you make your own slusher pins, the cost may be high and you may not get the best possible results. As a customer service, CF&I makes available Slusher Pins made to the same high standards of quality, performance and minimum cost as our Expansion Type Rock Bolts. Modified CF&I Rock Bolts also make excellent hangers for such equipment as air and water pipe, electrical cable, vent tubes and ventilating fans.



CF&I Slusher Pin—consisting of a ¾" bolt threaded at one end, and a 2¾" I.D. eye formed and welded on the other end. These are anchored in 1⅜" diameter holes by means of Pattin Type D-1 expansion shells, and successfully withstand the pull from slusher drums.

A 20-min. Rock Bolting color movie "Make Mine Safety" is available for showing, through the offices listed below.

THE COLORADO FUEL AND IRON CORPORATION

Albuquerque • Amarillo • Billings • Boise • Butte • Chicago • Denver • El Paso • Ft. Worth • Grand Junction • Houston
Kansas City • Lincoln • Los Angeles • New Orleans • Oklahoma City • Oakland • Phoenix • Portland • Pueblo
Salt Lake City • San Antonio • San Francisco • San Leandro • Seattle • Spokane • Wichita
CANADIAN REPRESENTATIVES AT: Calgary • Edmonton • Vancouver • Winnipeg

On the roughest SEALTITE electrical

against oil, grease, water, dirt, chemicals, corrosive fumes, salt spray, weather.

SEALTITE is a flexible *and* liquid-tight electrical conduit. It gives maximum protection to your wiring when it must connect moving parts, absorb vibration, follow machine contours, flex into U-bends, be easily maintained or be safeguarded between misaligned outlets.

It is being used successfully in wet locations, in tunnels, power plants, steel mills, canneries, chemical industries and in many outdoor applications. Sealtite comes in three types:

TYPE U.A.— TYPE C.S.A. Specifications for Type U. A. (Underwriters' Laboratories Approved) and Type C. S. A. (Canadian Standards Association Approved). Construction: flexible galvanized steel core, positive ground and tough extruded outer cover.

TRADE SIZE	INSIDE DIAMETER		OUTSIDE DIAMETER		APPR. INSIDE BEND	EST. WGT.
(Ins.)	Min.	Max.	Min.	Max.	DIAM.	(Lbs. Per 100 Feet)
⅜	.484	.504	.690	.710	6	30.0
½	.622	.642	.820	.840	7	36.6
¾	.820	.840	1.030	1.050	10	48.2
1	1.041	1.066	1.290	1.315	12	87.7
1¼	1.380	1.410	1.630	1.660	15	116.5

TYPE E. F.† (Extra Flexible)—for machine tools and industrial equipment. (Meets standards set by J.I.C.)

TRADE SIZE	INSIDE DIAMETER		OUTSIDE DIAMETER		APPR. INSIDE BEND	EST. WGT.
(Ins.)	Min.	Max.	Min.	Max.	DIAM.	(Lbs. Per 100 Feet)
⅜	.485	.500	.695	.710	5	24
½	.620	.635	.825	.840	5	29
¾	.815	.830	1.035	1.050	6	39
1	1.030	1.050	1.295	1.315	8	67
1¼	1.370	1.390	1.635	1.660	10	87
1½	1.575	1.595	1.875	1.900	12	105
2	2.020	2.040	2.350	2.375	15	135
2½	2.480	2.505	2.850	2.875	20	198
3	3.070	3.100	3.470	3.500	26	282
4	4.000	4.040	4.460	4.500	34	414

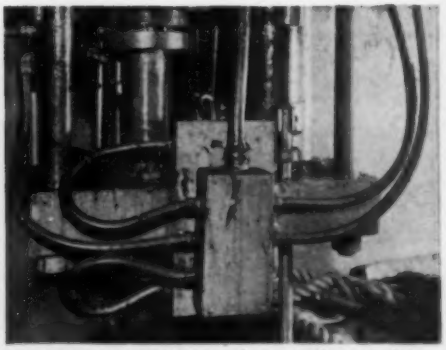
Commercial tolerances apply on above figures.

ELECTRICAL WHOLESALERS stock Sealtite. Buy it in long, random lengths on nonreturnable wooden reels, at no extra cost. Available in sturdy cartons that are easier to store and carry to the job. Liquid-tight connectors also are available from wholesalers' stocks. For information write: The American Brass Company, American Metal Hose Division, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

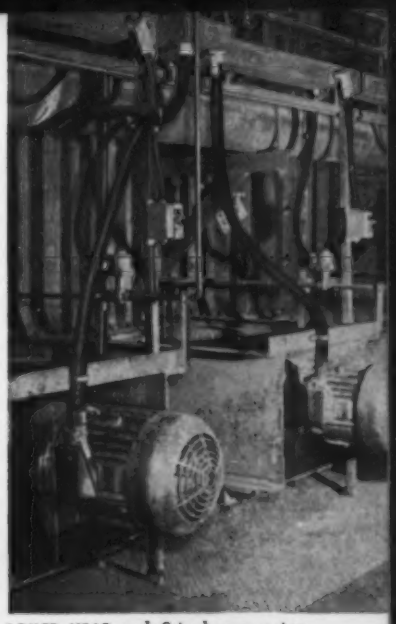
†Pat. applied for

jobs in your plant conduit protects wiring

ABRASIVE GRIT around these sand pumps in a rod and ball mill pit can't faze Sealtite.



OIL, GREASE, WATER constantly cover these Sealtite control connections. Still no trouble.



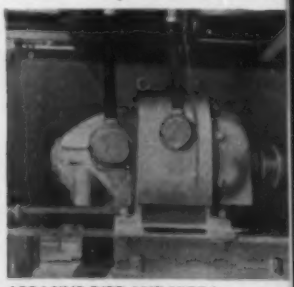
BOILER HEAT and 6-inch expansion rise are easy service for Sealtite.

CHEMICALS. Sealtite shrugs off hot chlorine vapors in this plant—another example of its ability to resist chemicals and corrosive fumes.

WEATHER. Install Sealtite outdoors. It stands up under tropical sun and heat, rain, ice, and arctic cold. Protection is complete.

ON MOBILE EQUIPMENT Sealtite can take up movement, withstands weather, dust, vibration. It's fast and easy to install.

MOVEMENT AND VIBRATION that would crack rigid conduit are absorbed by Sealtite on connections for these tailings pumps.



ABRASIVE DIRT AND VIBRATION at this ball mill motor are tough enemies—but Sealtite can take it.

CUTAWAY SECTION of Type U.A. Sealtite shows tough polyvinyl jacket over flexible metal core. Copper conductor wound spirally inside conduit gives positive ground.

Insist on the conduit marked

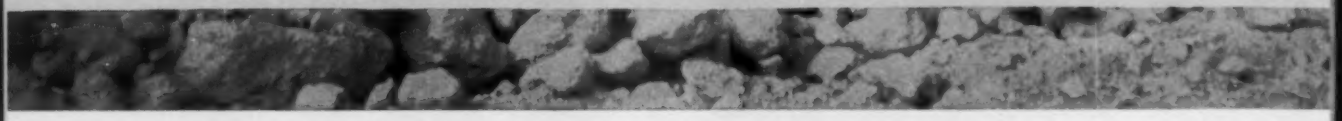
SEALTITE®

FLEXIBLE, LIQUID-TIGHT CONDUIT

an **ANACONDA®** *product*

Ripper production up 50%—costs down 25%

Dozing production up 20%—costs down 10%



—with a Caterpillar D8 Tractor with No. 8 Ripper and No. 8U Bulldozer!

There has been steady improvement in the production efficiency of the Ocala Lime Rock Corp., Ocala, Florida. Previous method of breaking up the lime rock was blasting. Then the firm turned to ripping with a Cat D8 Tractor and a tow-type ripper. The final step has been the addition of the advanced tractor-mounted No. 8 Ripper and No. 8U Bulldozer to the D8. Now production is up to 400,000 tons per year.

L. W. Fielding

Reports L. W. Fielding, superintendent: "The D8 with No. 8U blade and No. 8 Ripper increased ripper production about 50% and reduced ripping costs per yard by 25%. The No. 8U increased 'dozing production 20% while cutting 'dozing costs 10%." And he adds: "It's been the continued good service and performance like this of our Cat-built Tractors and Engines that have kept us in the Caterpillar family 18 years."

The D8, with modern, scientifically-designed U-shaped bulldozer and the tractor-mounted ripper, can increase production at your mine, too. Today's D8 is more powerful, more durable than ever before. Outstanding features include special rock track shoes—and the exclusive Caterpillar oil clutch, which operates for thousands of hours without adjustment.

Your Caterpillar Dealer has the whole story. Call him for the facts and a profit-proving demonstration.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR

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FIND YOUR CATERPILLAR DEALER IN THE YELLOW PAGES

BOOST PRODUCTION, CUT COSTS WITH THE D8

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Editorial Production: Marianne Snedeker

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The AIME also publishes:
Journal of Metals—monthly
Journal of Petroleum Technology—monthly
Transactions of The Metallurgical Society—bimonthly

"Printing is the lifeblood of industry." Printing and the problems of reproduction in producing MINING ENGINEERING may seem remote to many in the mining and minerals industry. Yet, communication is the responsibility of every industry and profession. In fact, communication comes into play within each plant or laboratory in the most preliminary stages of any project, large or small.

In late September a forum took place in New York on the latest developments in printing techniques. What does this have to do with mining and minerals? Of the eight revolutionary devices demonstrated, three are the result of research and development by firms vitally concerned both in the production and processing of minerals. The printing industry always has been—and will continue to be—dependent on metal products: for machinery, photographic plates, and type materials.

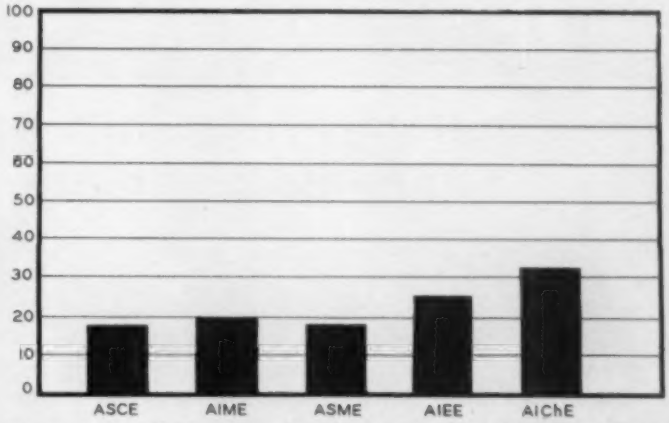
The minerals industry today is vitally concerned with the developments of new uses of metals and minerals, and with industrial statesmanship, as well as salesmanhip. The significance of this was amply demonstrated: a metal producer pioneering a radically new technique for etching photographic plates, a chemical and minerals firm developing an inexpensive timesaving printing plate, a mining and manufacturing firm experimenting with solutions for printing press problems.

One of the new developments demonstrated was particularly significant in connection with advertising plates. The ads in this issue are printed from plates, many used by several publications. Handling these plates is a major problem to both agencies and publications and there would be great savings for all if a film negative or positive print could be converted into a relatively cheap and efficient plate. Commercial production to do this is not far off. The implications are great.

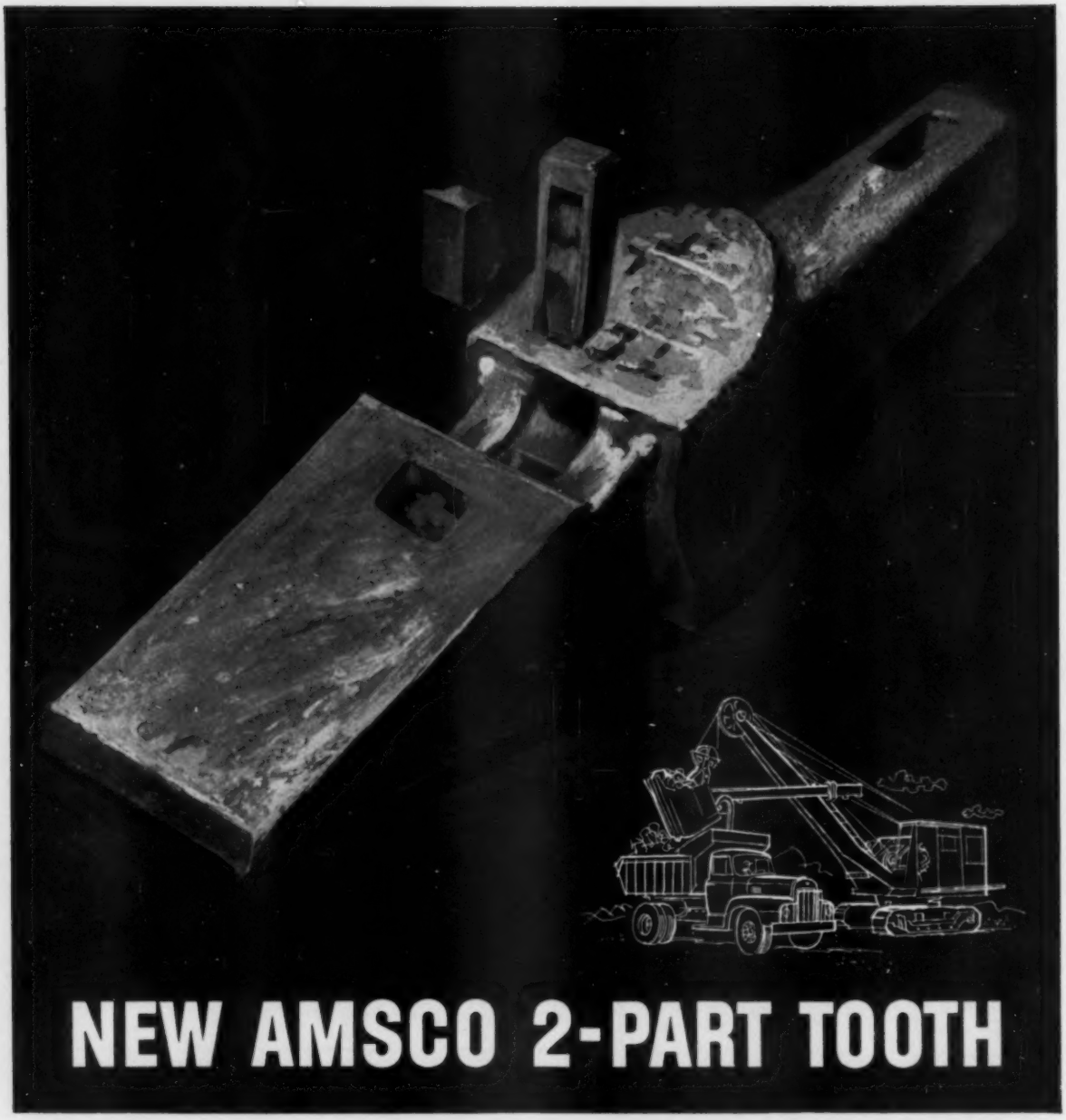
MINING ENGINEERING and AIME in general constantly study technical developments in printing and reproduction—adopting them where and when they fit our scale of operation and needs. (The "new look" in recent issues of MINING ENGINEERING is one result of this study—as is our present engraving process.

The staff of MINING ENGINEERING would like to point out that the trade and professional publications, advertising agencies, and industry firms will shortly have a tremendous opportunity to lead the way in a revolutionary printing development.

After this item had been written, our enthusiasm for the new printing processes was corroborated by lengthy articles in such business publications as *Business Week*, *The New York Times*, and other financial news media.—*R. A. Beals*



Progress in the Member Gifts Campaign for the new United Engineering Center is shown graphically. Each of the Five Founder Societies' pledges is plotted against the percentage reached of the respective goals. The bars are based upon October 17 totals as reported by the Building Fund. Note that AIME has reached, in pledges received, about 20 pct of its goal.



NEW AMSCO 2-PART TOOTH

Special-alloy reversible tips *(easy to reverse)* nearly double tooth digging life...

In quarry work, in cold and hot slag pits... in the roughest of digging tests, these new Amsco® 2-part Simplex teeth have outlasted competitive 2-part teeth more than 2 to 1... at a big saving in tip and adapter replacement time.

You get this longer wearing quality because of the special, rugged alloy used for both tip and adapter. Reversing tips extends digging life even more, yet takes only a few minutes.

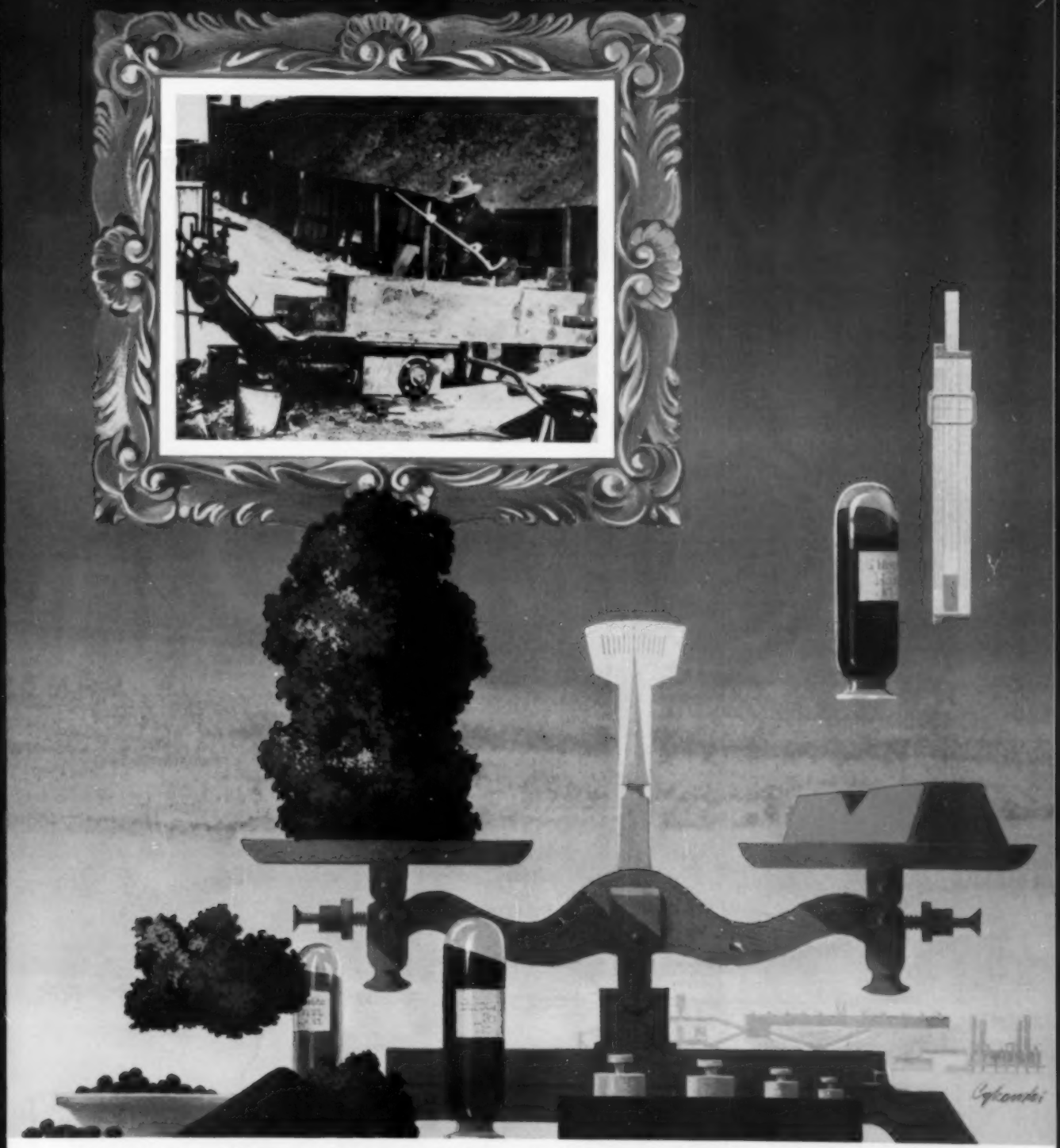
Adapters outlast several sets of tips, are equally easy to replace. Pin lock between tip and adapter seats and locks so securely, metal-to-metal, that even side blows can't jar it loose.

We'll be glad to send you a booklet containing reports by Simplex users and describing this new Amsco tooth completely. Write for it today.

AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Illinois



The Cake that Dwight and Lloyd baked, and patented. *Only a pallet full of sinter, but easily*

WORTH ITS WEIGHT IN GOLD

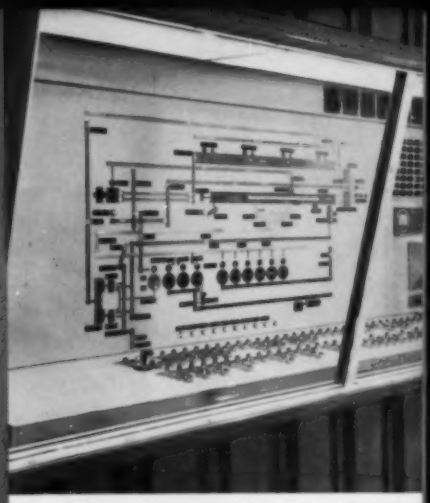
Historical dates in Continuous Sintering

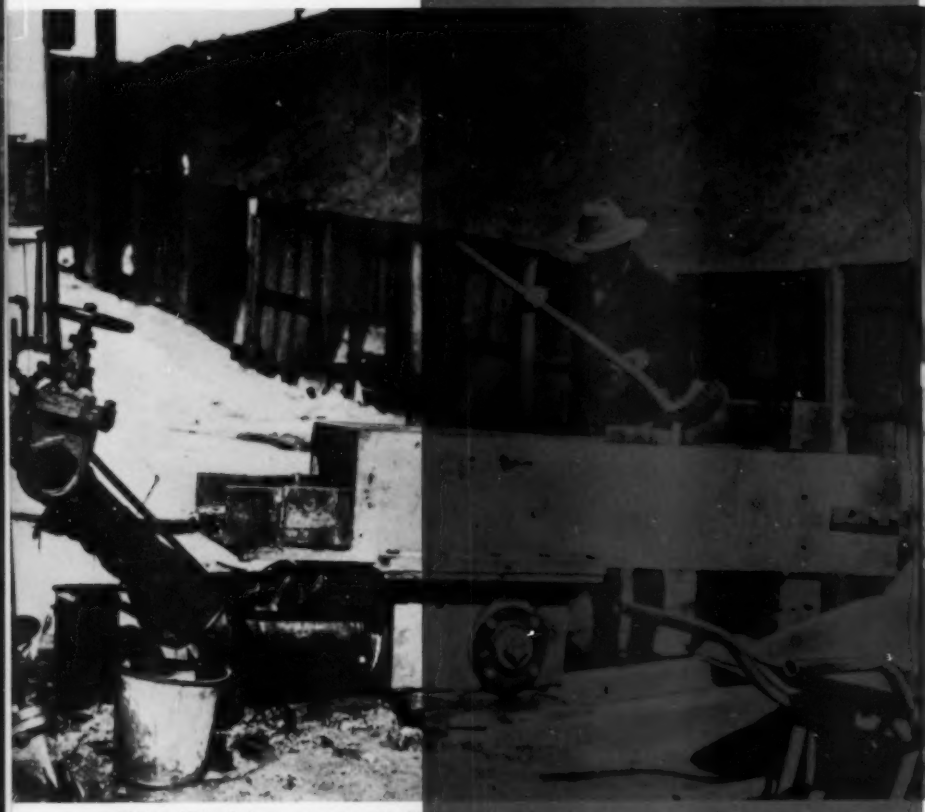
1906 The continuous sintering process was invented by Arthur S. Dwight and Richard L. Lloyd following extensive experiments at the Greene Consolidated Smelter in Cananea, Mexico. Patent was applied for.

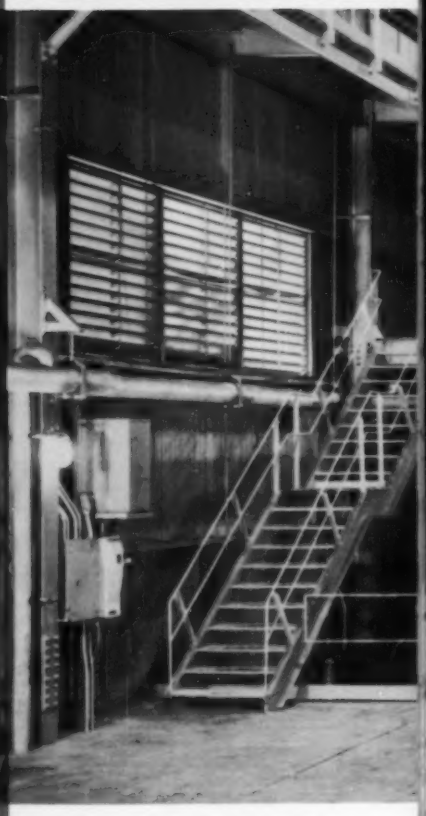
1908 The first patents on the process were granted.

1908 Dwight and Lloyd applied for a patent on the product – a cake of sinter – which was granted.

1908 The first commercially successful continuous sintering plant was installed at Salida, Colorado at a multi-metals smelter. It marked the establishment of the "straight line" or classic machine, the design that endures to this day.







Richard Lloyd shown charging the Dwight-Lloyd invention machine on the day the continuous sintering process was born. An original photo, preserved in the Dwight-Lloyd historical archives.

1908 Dwight began his first investigations of a sintered beneficiated blast furnace charge for ferrous industries.

1909 Dwight and Lloyd granted a license to Lurgi-Gesellschaft to build sintering equipment under the Dwight-Lloyd patents.

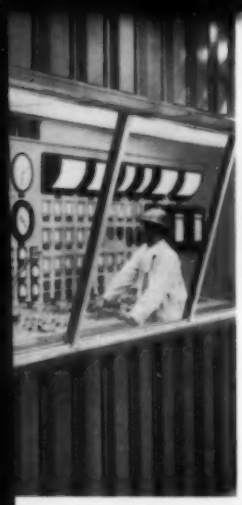
1911 The first ferrous sintering plant was installed at Birdsboro, Pennsylvania. The plant was designed by Dwight and Lloyd and delivered by a licensee, American Ore Reclamation Company.

1920 The Dwight-Lloyd Research Laboratories were established to fully investigate minerals processes.

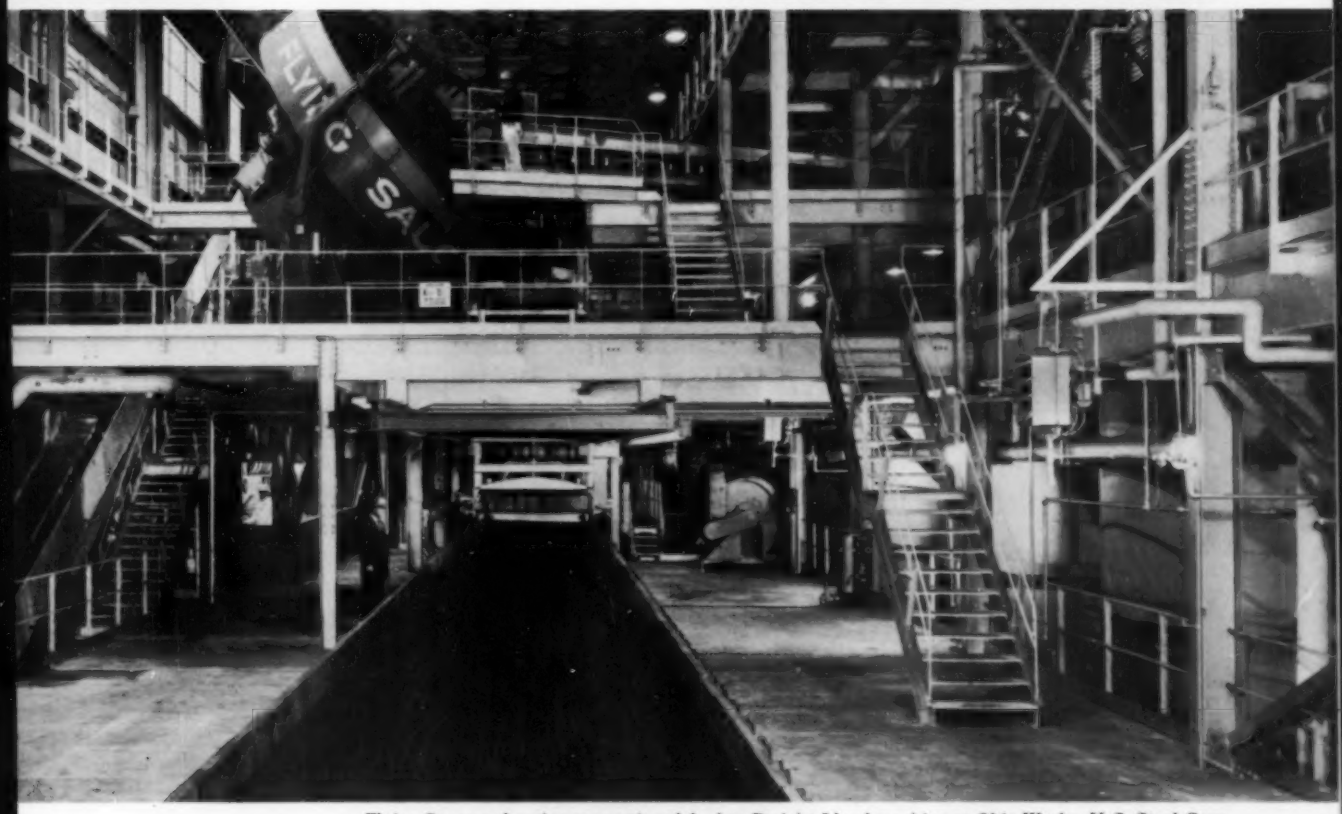
1955 McDowell Company, Inc. acquired the business and assets of Dwight and Lloyd, including the Laboratories, and moved them to Cleveland, greatly expanded.

Now

50 YEARS
DWIGHT·LLOYD®
CONTINUOUS SINTERING



Left, automated control center for new 5,000 ton per day single strand ferrous Dwight-Lloyd® sintering plant. Above, general view of plant. Right, the McDowell-developed Flying Saucer®, unsurpassed as a sinter mixing and pelletizing disc.



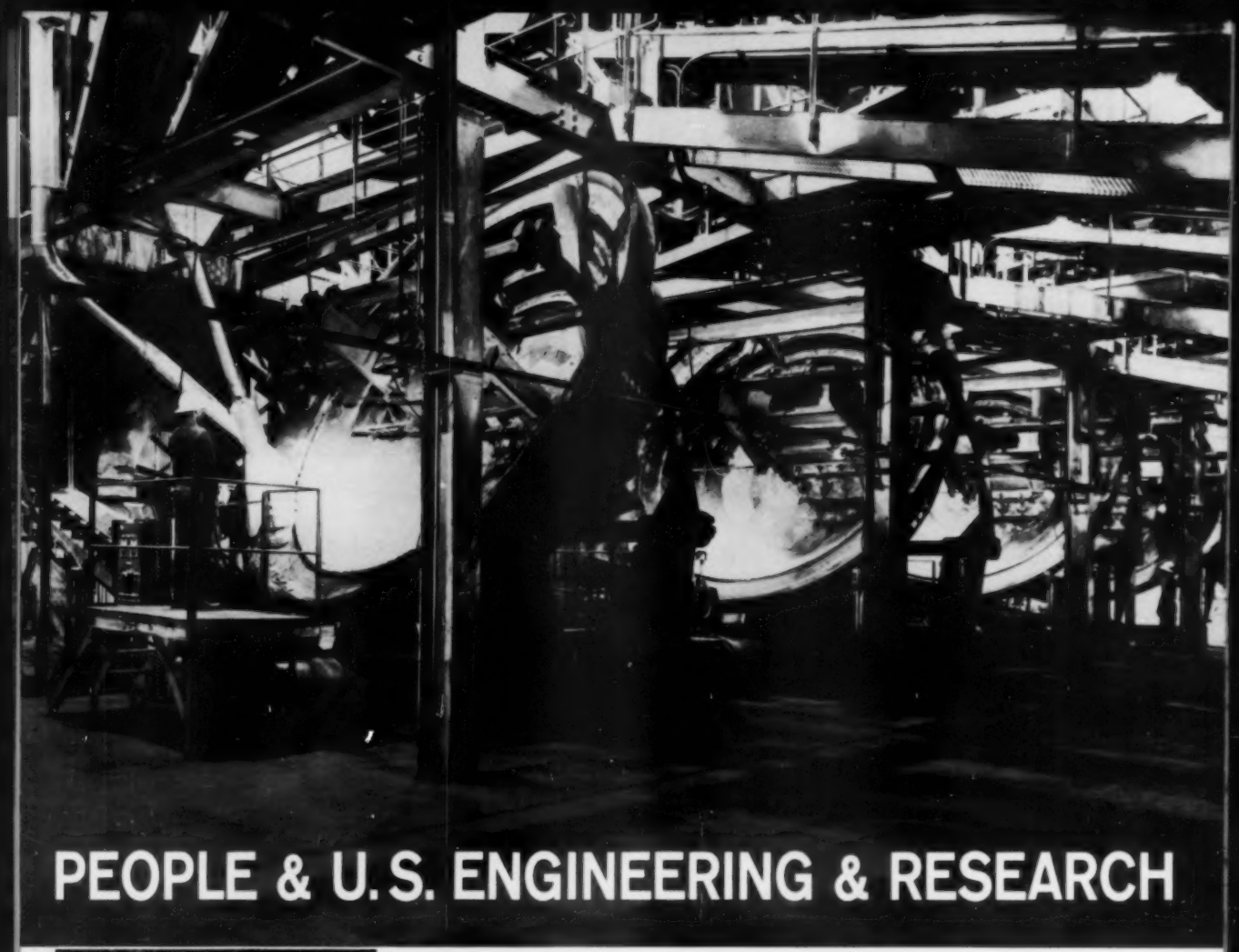
Flying Saucers charging proportioned feed to Dwight-Lloyd machine at Ohio Works, U.S. Steel Corp.

DWIGHT-LLOYD SHOWS SINTERING'S GOLDEN ERA

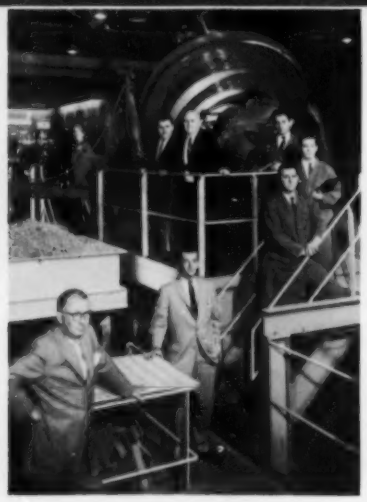
Big production ferrous installations are the newest Dwight-Lloyd sintering plants, developed to increase capacities of high-investment blast furnaces through beneficiation of raw materials. This acknowledges the work of our illustrious ancestors, the American metallurgists Dwight and Lloyd, who invented and pioneered continuous sintering, and proved to Illinois Steel Co. in 1908 the economical merit of sinter as blast furnace feed.

Culminating fifty years' practice, today's rugged Dwight-Lloyd plants reflect advanced McDowell engineering *and U.S. tonnage experience* in 1) proportioning and blending, 2) ignition, 3) burning and 4) cooling – all pilot-plant-proved in our famous Dwight-Lloyd Research Laboratories, established by the inventors in 1920, busy ever since on behalf of an international clientele engaged in all phases of minerals processing. Exclusive: Wellman hell-for-stout fabrication.

Dwight-Lloyd Division, McDowell Company Inc. • Cleveland 10, Ohio, U.S.A.



PEOPLE & U.S. ENGINEERING & RESEARCH



Key Dwight-Lloyd® personnel, at left, photographed in the Lab. *Counterclockwise from left:*

ROBERT C. McDOWELL, *President*, McDowell Company

PATRICK V. GALLAGHER, *Vice President*, McDowell Company

THOMAS E. BAN, *Director of Research*, McDowell Company

CHARLES D. THOMPSON, *Assistant to the Director of Research*

CHARLES A. CZAKO, *Research Metallurgist*

HAROLD E. ROWEN, *General Manager*, Dwight-Lloyd Division

ALLEN R. ROWEN, *Chief Project Engineer*, Dwight-Lloyd Division

experience explains Dwight-Lloyd® leadership in continuous sintering

SERVING a world-wide clientele in a multitude of ferrous and non-ferrous applications, Dwight-Lloyd continuous sintering is the bonanza of today's minerals processing. Our thoroughly American engineering approach delivers custom-tailored pyrometallurgical plants distinguished by the McDowell-developed Flying Saucer®, a superior mixing disc, and our ABCs® Belt Scale.

Conclusive pilot plant work at our famous Dwight-Lloyd Research Laboratories, also founded by the inventors of the continuous sintering process, adds reputation and confidence to Dwight-Lloyd — *the granddaddy of them all and still the best.*

SINTERING AT DWIGHT-LLOYD® DIVISION

McDOWELL COMPANY, INC., CLEVELAND 10, OHIO, U.S.A.

The McDowell Family of Related Enterprises—*McDowell Turnkey Plants • Dwight-Lloyd Research Laboratories Wellman Bulk Materials Handling Systems and Steelmaking Machinery • Anker-Holth Power Cylinders Dwight-Lloyd Ore Beneficiating Plants • ABCs Belt Conveyor Scales • Williams Buckets • Wellman Locomotive Cranes*

SOLVENT EXTRACTION AT VITRO

By W. B. HALL and JOY D. LEWIS

Mine-run ore is received at Vitro in gondola cars and fed directly to a Cedar Rapids impact crusher. Following screening, the undersize travels through a recently installed three-stage sampling plant where successive cuts are executed by conventional Geary-Jennings type cutters to produce a final sample of 1 lb per ton of raw ore fed. Crushed ore is transported to one of three storage silos or to stockpile, depending upon grade and type of amenability. This permits the blending of a mill feed with some degree of consistency.

Final grinding is accomplished in one of two closed circuit ball mill-classifier systems allowing simultaneous processing of two basic types of ores. High acid consumers may be leached separately in the required environment. Part of the free acid remaining can then be utilized by an ore stream entering later whose component ores require much less free acid for leaching.

Following leaching with sulfuric acid and sodium chlorate, the slurry is treated with an aqueous solution of sodium sulfide. Some undesirable ions such as molybdenum and copper are precipitated and follow the solid gangue which is discarded. Of greater importance with respect to solvent extraction is the reduction of iron to the ferrous form, which renders it relatively non-extractable from the pregnant liquor.

The countercurrent decantation operation follows sulfide precipitation and delivers clarified liquor to the solvent extraction plant, where uranium values are extracted, concentrated, and precipitated.

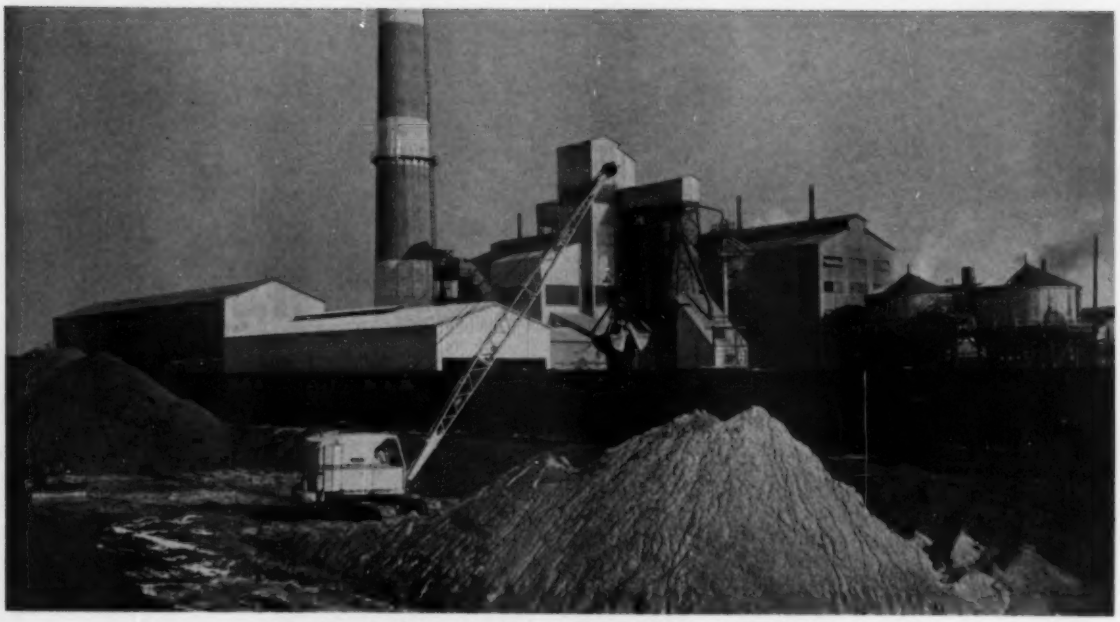
W. B. HALL and J. D. LEWIS are President and former Senior Research Chemist, respectively, with Vitro Uranium Co., Salt Lake City.

As a result of considerable exploration in the field of solvent extractive metallurgy, primarily by organizations under AEC contract, including the U. S. Bureau of Mines, two general types of solvents were discovered which were particularly suitable for uranium extraction. These were the orthophosphoric acid esters of primary and secondary long chain alcohols and secondary and tertiary alkyl amines. These are, respectively, liquid cationic and anionic exchange solvents.

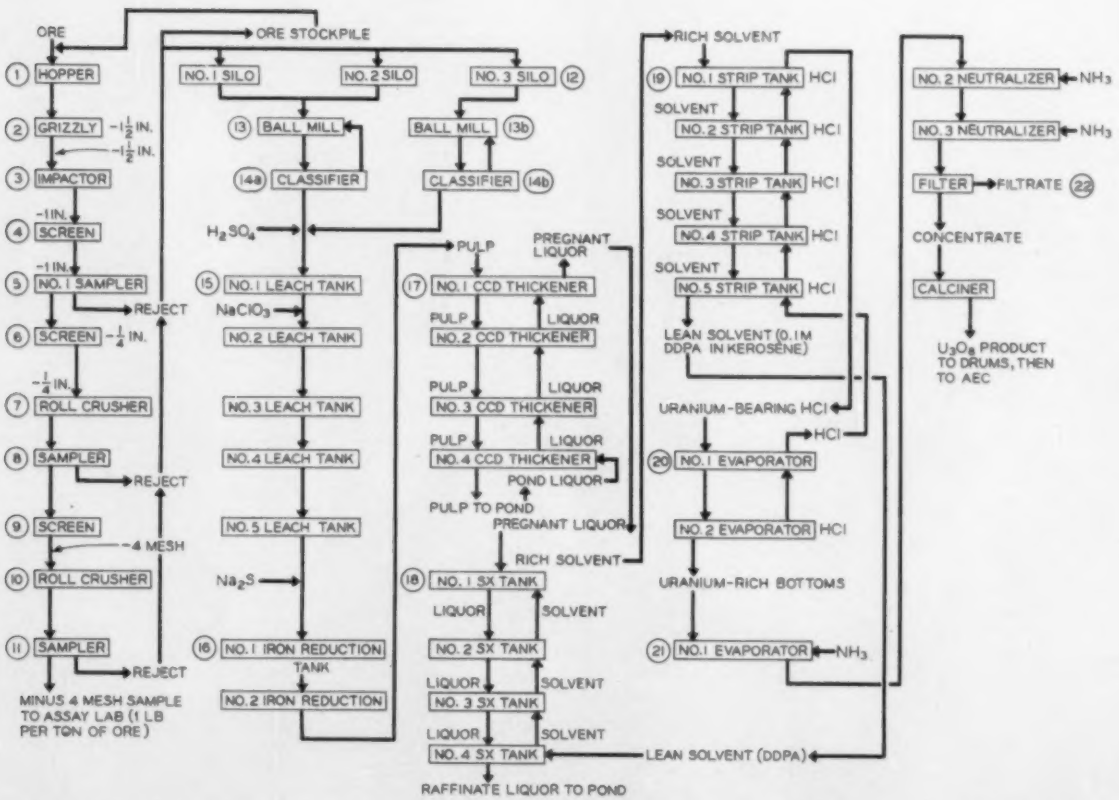
Following careful and thorough evaluation of merits of each type, including pilot plant exploration, the orthophosphoric acid ester of the secondary alcohol, 2, 6, 8, tri-methyl-nonanol-4, was selected for use at Vitro Uranium. This is commonly known as DDPA, or dodecyl phosphoric acid. Choice was also influenced by a combination of economic factors, including ease of procurement of the raw materials and a high degree of recovery of chemicals for re-use.

Preparation of this solvent is accomplished readily in the plant. Stoichiometric quantities of phosphorous pentoxide and the alcohol are reacted in sufficient kerosene to control maximum temperature at 70°C. The esterification requires less than an hour and results in the pyro product, which is subsequently cleaved. The succeeding hydrolysis is achieved by addition of a half volume of 1 *N* hydrochloric acid at 75° to 85°C for approximately 40 hr. This treatment yields approximately 90 pct of the theoretical quantity of approximately 1 *N*. Final dilution to a 3 pct solution is made with kerosene, and the reagent is blended into the plant inventory as needed.

Contact of this solution with the pregnant acid solution of uranium, primarily in the hexavalent



Ore is moved from stockpiles to plant at Vitro's installation



1. Railroad cars deliver ore from various mines to Salt Lake City, cars feed into 50-ton hopper 2. Grizzly with 1½-in. openings 3. Cedar Rapids 30x30-in. impact crusher 4. Hummer screen, 1-in. openings 5. Primary sampler takes 10 pct cut, sends rest to silos 6. Hummer screen, ½-in. openings 7. Roll crusher, 14x30-in. 8. Second sample is cut 10 pct with reject passing to silos 9. Four-mesh Hummer screen 10. Roll crusher set at 4 mesh 11. Final sampler delivers −4-mesh fraction to lab for assay (1 lb per ton of ore) 12. Three silos. No. 1 and 2 hold 900 tons, No. 3 holds 500 13a. Eimco 6x6-ft ball mill. Pulp at 70 pct solids 13b. Second 6x4½-ft ball mill treats ore from No. 3 silo. Pulp is at 70 pct solids 14a. Model C, Dorr-type rake classifier, 54 in. 14b. Spiral classifier 15. Five leach tanks (each 10,000 gal capacity) in series. H_2SO_4 added to first $NaClO_3$ to second and Na_2S to discharge from No. 5 16. Two agitator tanks for iron reduction 17. Four 70-ft Dorr-type thickeners in counter-current arrangement. Pond liquor and fresh water are used as wash liquor 18. Four SX tanks in counter-current series. Raffinate goes to pond, rich solvent to strip 19. Five-stage counter-current HCl stripping tanks. 10 *N* HCl used to strip. Lean solvent moves forward to SX section 20. Two-stage HCl evaporator and recovery section. Uranium-rich bottoms go to neutralization 21. Three-stage neutralization tanks Nos. 1, 2, 3. 22. Vacuum filter

Vitro's solvent extraction plant at Salt Lake City

state, effects transfer of the uranyl ion to the organic phase. Completeness of transfer is a function of the relative concentrations of uranium in the organic and aqueous phases and is favored by high solvent concentration. Among other ions extracted in varying degrees are titanium, aluminum, vanadium, and iron. Ferric iron is extracted to a greater degree than the others, and ferrous iron is extracted to a lesser degree. Transfer time for uranium extraction is of the order of 2 min or less. The extraction phase of the process is accomplished in a series of four internal mixer settlers. Organic and aqueous phases travel in countercurrent fashion, with both phases fed into the top of a given extraction tank and contact effected by use of a shrouded mixer impeller suspended above the phase boundary.

Stripping is accomplished by reaction with 10 *N* hydrochloric acid in a 10:1 organic to aqueous ratio. Time required for transfer of the U_3O_8 to the HCl is of the order of 20 to 30 min. Physically, the stripping operation includes five sets of mixer settlers which contact the loaded organic with the HCl in countercurrent fashion. Each set consists of two tanks of equal size with two parallel connections. One is fitted with an agitator for mixing, with the second performing the settling operation.

A slip stream of the lean organic returning to the extraction side is contacted with a solution of ammonium fluoride acidified to a pH of 5. This is a secondary stripping operation. The fluoride solution is effective in removing those metal ions that are more tenaciously held and are not removed by the HCl stripping treatment. Among these are thorium, aluminum, iron and titanium. These first three precipitate as fluorides together with some UF_4 and are removed by filtration. The fluoride solution is then adjusted to 8 pH with anhydrous ammonia to precipitate the titanium as a hydroxide. Filtration removes this product, and the fluoride solution is regenerated for further use.

Loaded HCl is fed to an evaporator to recover a major portion of the acid. This unit will be described later in greater detail. Evaporator bottoms containing uranyl chloride are diluted with water and precipitated by three-stage neutralization employing gaseous ammonia. After filtration, the diammonium uranate is calcined to drive off all moisture and sublime the ammonium chloride. The dried product is then packaged for shipment.

The hydrochloric acid recovery unit of the solvent extraction plant is unique in some respects. It performs an essential recovery function and returns over 90 pct of the available hydrochloric acid from the rich HCl solution to the stripping unit at a concentration of 10 *N*.

The unit consists of a two-stage, vertical-falling film-type evaporator, a dehydrating unit, and a condenser. Rich hydrochloric acid containing approximately 100 gpl U_3O_8 is fed to the top of the primary evaporator. Even distribution of the feed to the evaporator column is maintained by 31 weirs which extend its length and provide a large area for vaporization of the HCl from a falling film of the feed stream. This primary unit is operated at 215°F. The base section of this unit is fitted with a horizontal discharge which carries the stream of wet gas to a mist separator.

This mist or phase separator contains multiple tear-drop obstructions projecting into the path of the vapor stream which present a large surface area upon which entrained solution may collect. Entrained solution is collected and combined with the primary evaporator bottoms.

A second discharge opening located in a vertical position at the base of the primary evaporator permits gravity flow of the bottoms to the secondary unit. These bottoms contain from 300 to 500 gpl U_3O_8.

The secondary evaporator unit has seven weirs for feed distribution. Operating temperature is maintained at 255°F. Bottoms from this unit (containing from 800 to 1000 gpl U_3O_8) are discharged through a cooler into a mixing tank for subsequent dilution and feeding to the precipitation section. The horizontal discharge tube from the secondary directs the

Uranium concentrates are dried and packed in this part of the Vitro plant.

wet gas to a knockout pot. This pot performs the same function as the mist separator, which is incorporated in the primary vapor line. Condensate is discharged from the knockout pot into the bottoms stream leaving the base of the secondary evaporator. Gas from this unit then enters a drying tower packed with 2-in. Karbate raschig rings through which sulfuric acid is flowing. As the wet gas rises through this tower, it is dehydrated by the H_2SO_4 and is directed to a small mist separator packed with Berl saddles to trap the entrained sulfuric acid. This dry HCl then joins the wet gas from the primary condenser at a point just beyond the primary mist separator, and the mixture is condensed. The recovery unit is operated to deliver 10 *N* hydrochloric acid.

Sulfuric acid leaving the tower is cooled and recycled to the tower. Concentrated acid is added as required to maintain a concentration of 75 pct sulfuric acid, and a bleed stream is sent to the leach circuit for use in extraction.

Steam to the primary evaporator is controlled by a ratio controller actuated by the flow of feed to this unit, while the steam to the second evaporator is controlled by the specific gravity of the hydrochloric acid condensate. A specific gravity recorder on the uranyl chloride bottoms from the secondary evaporator resets the ratio controller on the steam feed to the primary unit. All equipment in the evaporator and condenser units is of Karbate or Teflon construction.

If operation of the solvent extraction unit is to be most satisfactory, proper attention must be given to liquor preparation, with particular reference to ferric iron content. Laboratory studies with confirmation in plant operation have given emphasis to this item.

It has been shown that DDPA has considerable affinity for ferric iron—to such a degree that extraction of plant liquors with this solvent prior to their reduction would be unfeasible. Laboratory data have shown that 1 mole of DDPA will extract 0.5 mole of uranium present in the hexavalent state. Under similar conditions 0.7 mole of ferric iron is extracted, although the exhibited valence of ferric iron would indicate extraction of only half this amount. Ferric iron is thus possibly attached to the DDPA as a complex, presumably as a sulfate. These results were obtained from DDPA extraction of simple solutions containing only the respective ions mentioned.

Once the ferric iron is extracted it is not removed but travels with the uranium to the final product. Inclusion of this iron would contribute to a more expensive and less efficient solvent extraction performance. Stoichiometric calculations indicate that 1 lb of extracted ferric iron requires 1 lb of HCl for stripping. This contrasts to only 0.31 lb of HCl required for stripping 1.0 lb of uranium. If, then, a DDPA solution containing 7 gpl of U_3O_8 and 2 gpl of iron were to be stripped, the same quantity of HCl would be required to remove the iron as to remove the uranium. Thus, contacting this theoretical DDPA solution of 7 gpl U_3O_8 and 2 gpl iron with a 10 *N* HCl solution in organic/aqueous ratio of 10:1 would reduce the normality of the acid to 9 *N* with each metal contributing half of the effect.

In the precipitation phase of the plant operation, a similar expense is involved if ferric iron is present. Assuming the precipitated uranium to be either diammonium (pyro-ammonium), uranate or uranyl hydroxide and the iron to be present as ferric hydroxide, 1.0 lb of uranium will require 0.14 lb of ammonia for precipitation, while 1 lb of ferric iron will requre 0.88 lb of ammonia. A further undesirable effect of extracted iron is that of contamination of final product, which necessarily lowers grade.

Extraction is also concerned with the ionic form of uranium. If the uranium is present as uranyl ion, the solvent is then capable of extracting 0.5 moles or 14 gal of U_3O_8 per l of 0.1 *N* solvent. If uranium is present in the reduced form, it is not found in combination with oxygen and exhibits a valence of +4, thus requiring twice as many sites, theoretically, for the loading of an equal amount of uranium. Saturation of the solvent would then be reached at a concentration of 7 gal of U_3O_8 per l. These observations suggest that the presence of uranium as the uranyl ion is most desirable and contributes to maximum extraction efficiency.

It is hoped that this presentation has given a brief picture of the Vitro operation and, also, that it has served to point out that solvent extraction is not without problems which require the careful surveillance and service of the metallurgical and chemical professions.

THE SHROUDED MIXER IMPELLER IN SOLVENT EXTRACTION OF URANIUM

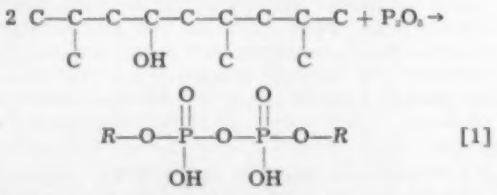
Hydrometallurgy and chemical engineering have been combined into a new science —chemical metallurgy. Here acid leaching and counter-current decantation are joined by liquid-liquid extraction to produce a refined uranium.

By L. D. LASH

The key to successful liquid-liquid extraction is the solvent. First, and most important, it must be highly selective for the metal desired and yet reject other metal ions present; second, the ideal solvent is completely insoluble in the aqueous feed liquor; third, it has rapid phase separation and will not form emulsions; and, fourth, low cost is desirable, since losses occur even though the solvent is recycled.

For this application a solvent known as DDPA (dodecyl phosphoric acid) was chosen since it closely met these requirements. DDPA is a long-chain alkyl phosphate developed for AEC by Oak Ridge National Laboratories, Dow Chemical Co., and the U. S. Bureau of Mines. The long chain contributes to low solubility in the aqueous phase and to high extracting power from acidic sulfate solutions, whereas the alkyl phosphates generally exhibit high selectivity for uranium solutions.

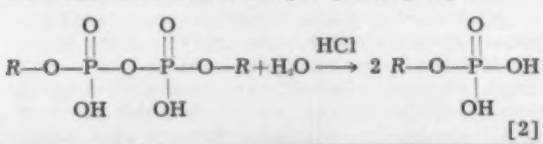
Eq. 1 shows how this solvent is prepared. A 12-carbon alcohol, technically 2, 6, 8 trimethyl-nonanol-4, is reacted with phosphorous pentoxide, P_2O_5, in a kerosene medium to form a pyrophosphate:



[1]

where *R* represents the alcohol radical. The remaining hydrogens are left off the carbon atoms for simplicity.

The pyrophosphate has two alcohol groups and two phosphate groups. As shown by Eq. 2, the pyro group is split by hydrolysis with dilute hydrochloric acid producing the mono-form of the solvent, which contains one alcohol and one phosphate group:

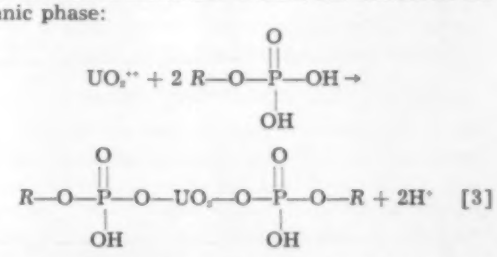


[2]

L. D. LASH is Plant Metallurgist with Vitro Uranium Co., Salt Lake City, Division of Vitro Corp. of America.

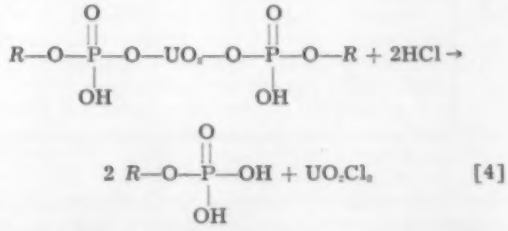
This concentrated DDPA solvent is diluted with kerosene to 0.1 *M* strength for plant use.

The mechanism for uranium extraction is shown in Eq. 3, where the uranyl ion is seen to combine with two DDPA molecules to form the extract in the organic phase:



[3]

The uranium is stripped by reacting the extract with strong hydrochloric acid, releasing the uranium as a uranyl chloride solution, and yielding lean solvent for re-use in extraction, as shown in Eq. 4:



[4]

The high selectivity of DDPA for uranium is illustrated by Fig. 1, a distribution curve of uranium between chemically reduced leach liquor and 0.1 *M* DDPA. In the high or concentrated range a pregnant liquor containing 1 gpl U_3O_8 after contact is in equilibrium with solvent containing almost 14 gpl U_3O_8. This multiplies metal concentration in the organic phase—a characteristic of liquid-liquid extraction of dilute solutions. Because of this concencentration factor, the volume of solvent handled is reduced to a small fraction of the aqueous flow.

But liquor containing 1 gpl U_3O_8 cannot be discarded. A multiple-stage contact system is used, therefore, to lower the aqueous uranium concentration to a minimum value. Stage by stage, step by step, the low range of the equilibrium curve is reached. Here, for example, an aqueous liquor con-

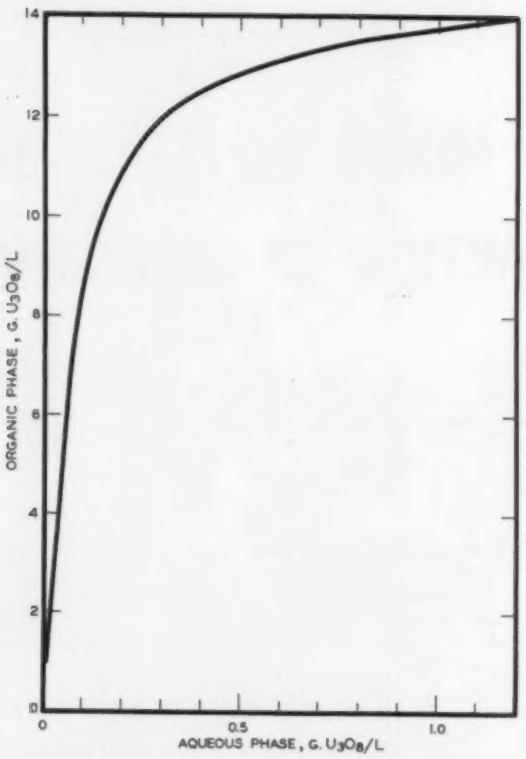


Fig. 1—Distribution of uranium between reduced leach liquor and 0.1 M dodecyl phosphoric acid in kerosene.

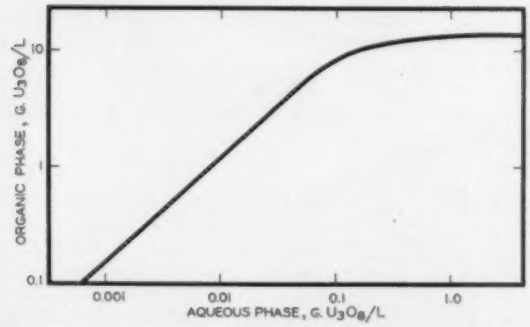


Fig. 2—Distribution of uranium between reduced leach liquor and 0.1 M dodecyl phosphoric acid in kerosene. (Same data as in Fig. 1, extended by log-log plotting.)

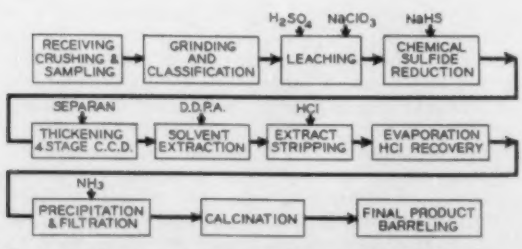


Fig. 3—Solvent extraction of uranium is added to a conventional acid leach process in a typical installation.

taining 0.1 gpl U_3O_8 after contact is in equilibrium with organic solvent holding 8 gpl U_3O_8—eighty times the aqueous concentration. This uranium concentration ratio of organic to aqueous phase is the *distribution coefficient*, a measure of solvent effectiveness. Ideally, the raffinate from a four-stage uranium extraction will be 0.002 gpl U_3O_8, yielding a 99.8 pct extraction efficiency. Fig. 2 shows the same distribution on a log-log plot. This type of graph expands the congested area in the dilute regions exhibited in Fig. 1, which was plotted on linear coordinates.

Solvent extraction of uranium is added to a conventional acid leach process in a typical installation, as shown in Fig. 3. The ore is crushed and ground, then leached with dilute sulfuric acid. Addition of an oxidant such as sodium chlorate insures conversion of uranium minerals to a soluble form. At this point the slurry is chemically reduced by a sulfide, such as sodium hydro-sulfide, to remove substances which are partially extracted by the solvent. The heavy metals, such as molybdenum, are removed as sulfides. Simultaneously, ferric iron is reduced to the ferrous form, which is essentially nonextractable in the solvent. The solids-liquid separation is accomplished by a four-stage CCD thickener circuit, with the tailings pond acting as a fifth thickener, since the pond water is returned.

The pregnant liquor, or unclarified thickener overflow, is then ready for solvent extraction by DDPA. This is accomplished in 20-ft diam extractor tanks, using a contactor with a shrouded mixer impeller. The organic phase containing the uranium is transferred to the stripping section, where 10 *N* hydrochloric acid removes the uranium from the solvent. The stripped solvent is recycled to the extraction section and used again.

In the evaporation section, the major portion of the hydrochloric acid is recovered for re-use. The concentrated heel from evaporation, now containing 1000 gpl U_3O_8, is neutralized by anhydrous ammonia and the slurry is filtered. The filter cake is then calcined in a roaster to remove impurities and yield the final U_3O_8 product of specification grade, ready for shipment to the AEC.

The contactor for extracting uranium could be drawn from many types of equipment, such as mixer-settlers, pump-mixers and settlers, pulse columns, and internal mixer-settlers (for example, the shrouded mixer impeller). Several factors must be considered, however, in selecting a liquid-liquid contactor:

1) **Chemical reaction rate:** DDPA solvent extracts uranium in a few seconds, so it has a fast reaction rate.

2) **Emulsion formation:** When the organic phase is continuous, emulsion formation with DDPA is slight, even though some solids are present.

3) **Economic considerations:** Use of just one tank for both contact and phase separation would reduce capital investment. Under ideal circumstances power costs, too, should be minimum.

The shrouded mixer impeller excels in each of these points. First, since the DDPA extraction rate is rapid, the short holdup time in the contactor is long enough to allow efficient uranium extraction. Second, while intimate contact is achieved, emulsion formation is suppressed because of a continuous organic phase created by the contactor. Third, initial cost of a shrouded mixer impeller is low and

only one tank is required for both mixing and settling. Power costs are low, too, since just the feed liquids and recycle are agitated, rather than the entire contents of the tank.

The shrouded mixer impeller, Fig. 4, consisting of feed lines, draft tube, hood ring, and impeller, provides an efficient mixing of solvent and aqueous liquor internally and allows undisturbed phase separation externally. The aqueous and solvent feed lines enter the draft tube, which is merely a pipe above the impeller. Solvent is recycled through the open top of the draft tube to provide a continuous organic phase during mixing. If desired, recycle solvent may also be admitted at the annular opening just above the hood ring. This hood ring or shroud, resembling an inverted dish with a hole in the center, isolates the impeller from the settling portion of the extractor tank.

The heart of the unit is the impeller, which performs the actual liquid-liquid contact. Here the organic solvent and aqueous feed liquor are intimately mixed to allow efficient mass transfer of uranium from the aqueous to the organic phase. The mixture is centrifugally thrown outward and slightly downward into the extractor tank where phase separation takes place.

The process and the contactor were developed at the same time. After shaker tests with the solvent, a bench-scale laboratory unit was set up using mixer settlers with separate pumps for organic recycle. Then the pilot work was carried out using the shrouded mixer impeller. The pilot plant simulated a single-stage unit operating under continuous conditions. This allowed maximum flexibility in the study of process variables.

Factors pertaining to the contactor that were studied in the pilot plant included draft tube configuration, impeller size, agitation speed, recycle ratio, emulsion formation, and the settling area required.

The shape of the draft tube controls the recycle flow pattern. In the gas-liquid contactor initially provided by the Turbo-Mixer Co., solvent was recycled through round holes in the draft tube. Later this tube was replaced by one without holes; an annulus at the base of the draft tube, just above the hood ring, was opened and closed by an adjustable ring so that flow effects could be observed. The final design incorporated a cylindrical draft tube with a 1-in. annulus at the base.

Impeller size was determined experimentally. Pilot plant design called for a 12-in. diam impeller in a tank 3 ft 6 in. diam, but experience gained in pilot operation dictated an impeller half this size in a tank twice the original diameter.

A certain minimum agitation speed was required for acceptable stage efficiency. The 6-in. pilot plant impeller provided 90 pct stage efficiency at 300 rpm. The first stage, where a major portion of the mass transfer took place, produced optimum results at 400 rpm. At greater speeds there were problems with emulsions and suspensions.

The recycle ratio inside the shrouded mixer impeller was controlled by two factors: first, the interface level between the organic and aqueous phases. This interface had to be maintained 24 in. below the impeller to provide a continuous organic phase and to prevent pumping of aqueous from below.

Second, the width of the recycle annulus determined the amount of recycle just above the impeller. When the annulus was closed, the entire recycle entered through the top of the draft tube. Note that the shrouded mixer impeller performed the pumping action for recycle, and no external pump was necessary.

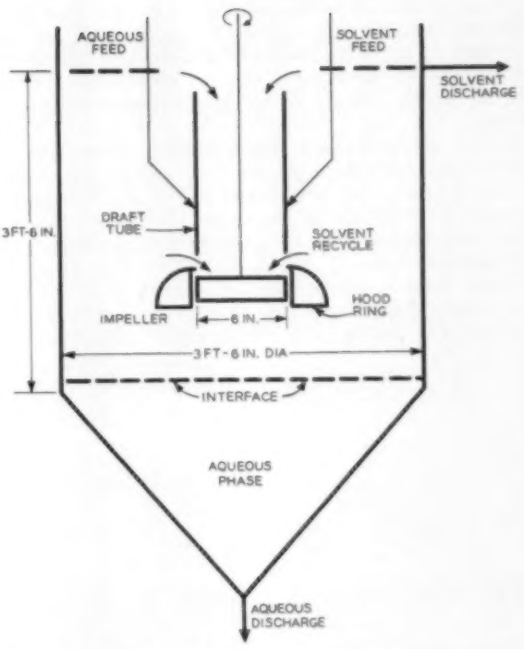


Fig. 4—With the shrouded mixer impeller, above, extraction rate is rapid. Little emulsion is formed. Initial cost of the unit is low, and only one tank is needed for both mixing and settling. Power costs are held to minimum.

Experiment showed that a recycle ratio of 3:1 organic to aqueous (*O/A*) was required to suppress emulsions and allow rapid breaking of the two phases. Since an excess of aqueous feed entered the extractor, a great deal of organic recycle was required. The shrouded mixer impeller easily accomplished this recycle at very low power consumption.

Emulsion formation was found to be chiefly a function of solids in the pregnant liquor. Since unclarified thickener overflow was being used, it was known that some solids would always be present in the feed. The DDPA solvent forms less emulsions than most other alkyl phosphates and much less than all amines when solids are present. This was a major factor leading to selection of this particular solvent.

The settling area required for this system is 1 sq ft for each 1.4 gpm of aqueous feed. That is, for each 140 gpm of aqueous feed, 100 sq ft of settling area must be provided. This factor was used directly to scale up to plant size. On this basis, the 20-ft diam extraction tanks are capable of handling 440 gpm of aqueous flow. Under all conditions the settling area has been more than adequate for actual plant operation.

Scale-up of the shrouded mixer impeller to plant size was based on the required *O/A* recycle ratio of 3:1. The manufacturer provided curves showing the pumping rates for different impeller sizes and the *normal* operating speed for each size. Owing to high shear effects by small impellers, there was greater tendency toward emulsion. The final selection,

therefore, was a large impeller to be run at a slow speed. This also allowed reserve capacity, since the contactors could be speeded up if desired. An 18-in. diam impeller with a 2-hp motor was chosen for the 20-ft diam extractors in the solvent extraction plant.

With the shrouded mixer impellers, plant start-up proceeded smoothly. Of the four extraction stages, only the first was run at 100 pct of rated impeller speed. The remaining stages produce high efficiency and less tendency to form emulsions at slower impeller velocities.

The solids temporarily contained in thickener overflows during start-up caused some emulsion to form, but during normal thickener operation the DDPA extraction of uranium proceeded automatically and efficiently, with little attention from the operators.

Solvent extraction may be advantageously applied to many metals besides uranium, especially to the semi-rare metals commanding a price of $1.00 to $100 per lb. At present the exciting pairs of zirconium-hafnium and columbium-tantalum are being separated and purified by solvent extraction. Tomorrow this list may be expanded to include beryllium, tungsten, rare earths, selenium, tellurium, thorium and others with ever-widening applications in this metals-dependent age.

REFERENCE

J. D. Moore: JOURNAL OF METALS, 1957, vol. 9, pp. 757-761.

SX—*plant report*

SOLVENT EXTRACTION AT GUNNISON, COLORADO

by H. L. HAZEN

The uranium mill at Gunnison, Colorado, started crushing ore Dec. 31, 1957, and has now been operating four months. The acid leached ore is washed by counter-current decantation through a system of four classifiers and four thickeners and most of the dissolved uranium reports in the overflow from the first washing thickener.

This uranium is extracted from the aqueous pregnant solution by solvent extraction using di-2-ethyl hexyl phosphoric acid and tri-butyl phosphate dissolved in a high-flash-point kerosene as the extracting organic. The pregnant organic is then stripped with soda ash solution. The uranium bearing soda ash solution is filtered to remove insoluble carbonates and any sediment reaching that part of the circuit. The clarified carbonate pregnant solution is then acidified to 3 pH, heated to 180°F to drive off the last traces of CO_2, and the uranium finally precipitated as yellow cake with MgO.

This solvent extraction method was developed at the Oak Ridge National Laboratory by a group headed by Keith Brown. Their published reports covering the system used at Gunnison have mostly been declassified and are readily available. Experience at Gunnison during these first four months of operation proves again the accuracy of their laboratory work.

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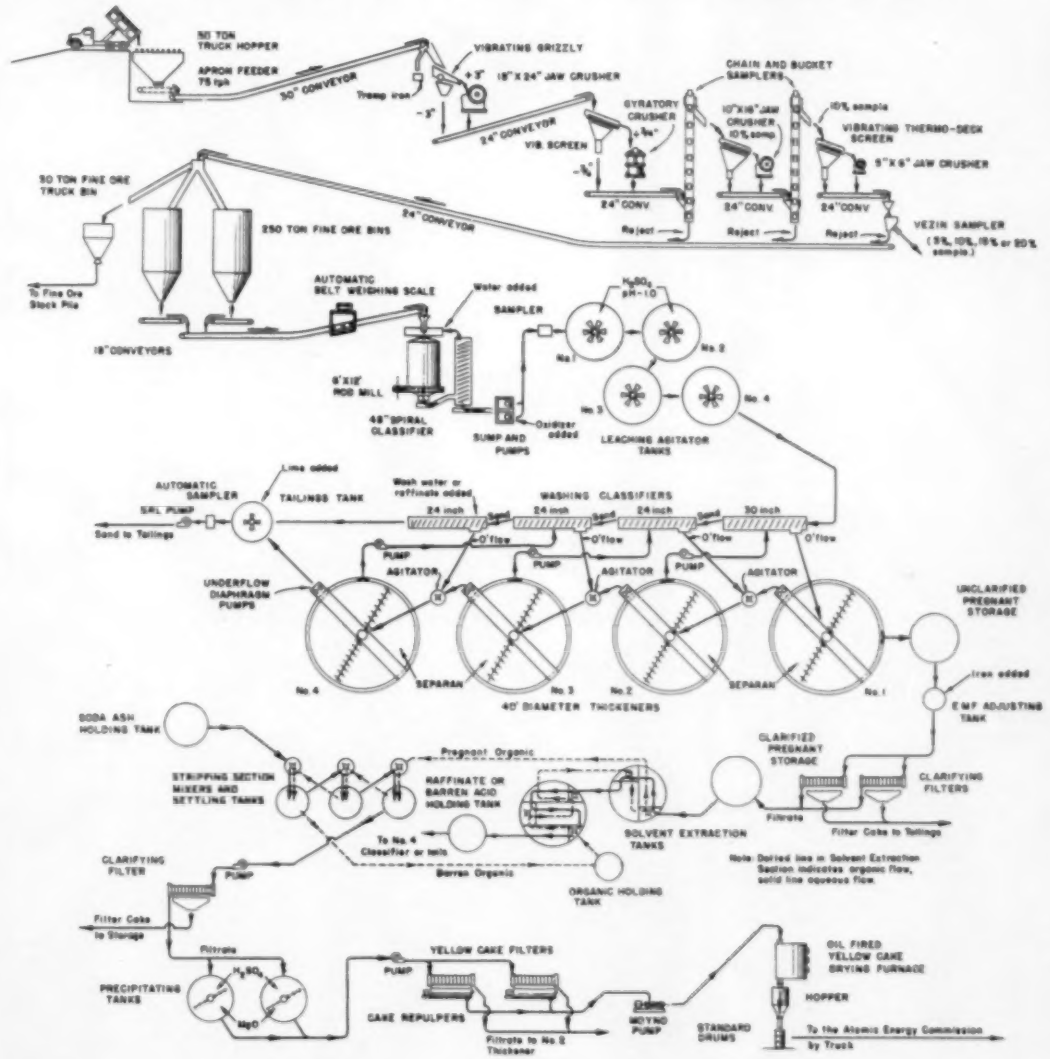
Consideration was given to the possibility of using an amine as the extracting organic at this mill. But amine organics were not commercially available when the Gunnison mill started operation and di-2-ethyl hexyl phosphoric acid and tri-butyl phosphate could be bought in any quantity. There was no alternative except to start the plant with the DEHPA process. However all equipment in the solvent extraction circuit was built of materials that could handle amine organics with acid-chlorides for elution, if the management ever decided to change from phosphate to amine organics.

Because di-2-ethyl hexyl phosphates extract ferric iron, but not ferrous iron, the mill has a reduction circuit ahead of SX in which any ferric iron in solution can be reduced to ferrous iron by passing the acid aqueous pregnant solution upward through a bed of tin cans. In practice it has been found that the ores now being treated at Gunnison contain such a small amount of ferric iron that this reduction step is not necessary.

Clarification filters are provided so that the acid aqueous pregnant solution may be polished before going to SX. This would be necessary if an amine were used as the extracting organic, but the small amount of slime in the aqueous pregnant solution has no deleterious effect on the DEHPA extraction circuit at Gunnison, as long as all mixers are run organic-continuous. So the polishing filters are not

URANIUM CONCENTRATOR FLOWSHEET — GUNNISON MINING COMPANY



used and the pregnant acid solution is sent to solvent extraction just as it overflows from the first washing thickener.

The extraction section consists of 5 mixer-settler units arranged in two round wood tanks The larger of the two tanks is divided into three compartments by two vertical wood partitions The smaller tank is divided into two compartments by one partition. Then each compartment is in turn divided into two parts by a vertical partition across one end. The smaller of these divisions is the mixing compartment, the other portion is the settler.

The aqueous pregnant solution flows to the first mixer and from that into the first settling compartment. Then the aqueous flows by gravity over a controlling weir into the second mixer and on into the second compartment, and so on through the system of five mixer-settler units. The extracting organic flows counter-currently through the system —advanced by airlifts from a settler to the mixer of the proceeding mixer-settler unit.

Seven different instruments were installed to control the solvent extraction circuit. Three instruments were to show the pH, the EMF and the rate of flow of the pregnant acid solution. Two instruments were to show the flow of the organic pregnant and the flow of the organic barren solution, and two instruments the flow of the soda ash stripping solution and the pH in the middle stripping settler. But not a single one of these instruments worked when the mill started. After four months of operation only one flow meter is working. The plant was started up and to a large extent is still operating with a wrist watch and a 14-qt pail to control the different flow rates. The Emf and the pH are still taken with hand meters.

The Gunnison operation found it important to run all five mixers organic-continuous. By this it is

Gunnison Solvent Extraction Circuit
Typical Operating Conditions

Aqueous Pregnant Solution	
Flow rate	150 gpm
Analysis	0.9 gpl U_3O_8
Temperature	100°F
pH	1.0
EHF	−400
Power consumed by mixing agitators	32 hp—continuous
Power consumed by pumps recycling organic	20 hp—continuous
Aqueous tails (Raffinate)	0.001 pct U_3O_8
Organic Extracting Solution	
Flow rate	30 gpm
Analysis	
Organic pregnant	4.5 gpl U_3O_8
Organic barren	0.02 gpl U_3O_8
Composition	
Kerosene	95.0 volume pct
Di-2-ethyl phosphoric acid	2.5 volume pct
Tri-butyl phosphate	2.5 volume pct
Soda Ash Stripping Solution	
Na_2CO_3	10 pct
Flow rate	3 gpm
Analysis—Soda ash pregnant	45.0 gpl U_3O_8
Temperature	120°F
Power consumed by mixing agitators	12 hp—continuous

meant that the mixture in each mixer consists of drops of aqueous dispersed through organic solution. In order to get this condition a flow of 150 gpm of organic is recycled from each settler back to the mixer that is partitioned off in the same compartment. The system ran aqueous-continuous for a while but the results were most unsatisfactory. Aqueous continuous means, of course, that drops of organic are dispersed through the aqueous medium. When operating the mixers aqueous-continuous the small amount of slime in the thickener overflow emulsified with the organic, tied up large amounts of organic in the system and made a mess that was difficult to handle. This problem was solved by recycling enough organic to run the mixers organic-continuous.

Each of the settlers has an area of 150 sq ft. The third mixer holds 600 gal. Mixers No. 1 and 2 each hold a little more and mixers No. 4 and 5 a little less. Each aqueous weir is 8 in. below the preceding weir. The organic level in each settler is 8 in. below the organic level in the preceding settler. Airlifts advance any organic that flows into the top of the boot that feeds the airlift and determines the organic level in that settler.

The raffinate from the fifth settler flows to a scavenger settling tank where a small amount of entrained organic collects on top of the aqueous and is siphoned off from time to time and returned to the circuit. The raffinate flows from the bottom of scavenging tank through a jack-leg and is pumped either to waste or to the CCD washing circuit.

The organic pregnant solution is sent to three mixer settler units where it flows counter-currently to 10 pct soda ash solution. These stripping mixer settlers are lined with polyvinyl chloride so that at some future date they could be used, if desired, to strip an amine organic with an acidified sodium chloride solution. The agitators are round tanks suitably baffled for proper mixing. Each settler is a cone, 8-ft diam at the top and tapering on a 60° slope to the discharge. In this stripping section the organic flows from mixer-to-settler-to-mixer by gravity while the soda ash solution is advanced counter-currently by airlifts from the bottom of the cone settler to the proceeding mixer.

Soda ash solution will strip any metal from di-2-ethyl hexyl phosphoric acid. The soda ash pregnant solution therefore carries with it a precipitate of any metal that is not soluble in soda ash solution, such as ferric iron or titanium. This precipitate is filtered out in a filter press. The sludge from the press is returned to the grinding circuit and the clarified soda ash pregnant solution flows to the precipitation tanks.

The clarified pregnant solution is first acidified to 3 pH, heated to 180°F to drive off all CO_2, and the uranium precipitated by addition of MgO up to 6.5 pH. A typical analysis of yellow cake produced at this plant is given in the following:

Analysis Gunnison Concentrate
February 26, 1958

	Pct
U_3O_8	80.60
V_2O_5	Nil
PO_4	0.27
Halogens, less F	Trace
F	0.01
Mo	0.30
SO_4	10.83
Fe	0.19
Cu	0.01
As (less than)	0.30
CO_2	0.02
Ca	0.01
Na	3.46
Ppm (less than)	.50
H_2O	0.342

The operation of the solvent extraction section at Gunnison has proven unusually simple and easy. One operator is assigned to this section on each shift but he has almost nothing to do and will have little to do until he is trained to analyze the solutions for uranium. This analytical work is now done in the main laboratory.

At two different times, when the afternoon shift foreman had a day off, the solution man on that shift was too sick to report to work. This mill operates so easily that the general superintendent did not bother to have either of these two jobs filled for those two afternoon shifts. On both days the afternoon shift was operated by the operator in charge of the grinding and leaching circuit, the product man and a helper. The general superintendent took a long chance in doing this because the manager might wonder why the mill needs a shift foreman and a solvent extraction man on any shift.

A set of typical operating conditions in the solvent extraction circuit at Gunnison are presented in the accompanying table.

Consumption of chemicals have been very close to the requirements predicted in the laboratory work reported by Oak Ridge. These chemical consumptions at Gunnison have been approximately those shown in the following data which include precipitation of yellow cake:

Sodium carbonate	2.2 lb per lb U_3O_8
Sulfuric acid to destroy carbonate	2.0 lb per lb U_3O_8
MgO for precipitation	0.2 lb per lb U_3O_8
Solvent organic loss	0.5 gal per 1000 gal of aqueous treated

The operation of the solvent extraction section at the Gunnison mill is another demonstration that this method will extract 99.9 pct of uranium dissolved in acid solution, is very easy to operate, and the chemical costs of recovering uranium from solution are competitive with the chemical costs obtained by any other process now in use.

BETTER ROADS FOR LOWER COSTS

By LUTHER M. KRUPP

Asphalt used for surfacing main open pit haulage road at Asarco's El Tiro mine in Arizona

A 3½-mile asphalt mixed mat haulage road joins American Smelting & Refining Co.'s El Tiro copper pit northwest of Tucson and its Silver Bell mill. Two-axle trucks operate continuously over the roadway but the asphalt top shows none of the *washboard* wear usually seen on dirt haulage roads during use by heavy vehicles.

The following data cover construction of this road, and results of its use by Asarco and Isbell Construction Co., the road's builder.

Within nine months after completion of the El Tiro road, Isbell hauled some 500,000 tons of ore over the road's 2½-in. mat. Most of the tonnage was delivered in the new 50-ton capacity Kenworth rear dump trailer trucks which supported single-axle loads averaging 80,000 lb. Some ore was hauled with Euclid FFD trucks, with tandem axle loads of from 120,000 to 130,000 lb. This is unusually heavy loading for asphaltic pavement—on highways state laws usually restrict truck axle loads on paved roads to 18,000 lb for single axles, and 32,000 lb for tandem axles.

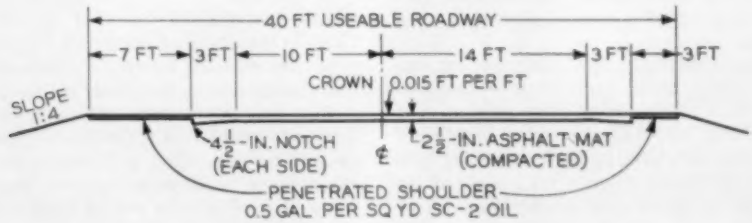
Starting at the El Tiro pit, at 2650 elevation, the road grades down to a low of 2615 ft and then climbs to 2780 elevation at the mill. Maximum down-grade is 2 pct and maximum upgrade is 2.5 pct. Minimum radius of curvature is 1000 ft. Super elevations were designed for a speed of 40 mph, and rotated about the centerline. Alignment and estimating were done on an aerial topographic map.

Specifications were in accordance with the Arizona State Highway Department, with special added provisions.

The finished roadway is 40 ft wide. From south to north this consists of a 3-ft wide penetrated shoulder, a 30-ft section of asphalt mix 2½-in. deep, and 7 ft of penetrated shoulder. Sub-grade was to be 6 in. of −1-in. compacted gravel of which a 30-ft width, 2½ in. deep would be windrowed to be mixed for the asphalt mat. A 0.015 ft per ft crown was called for.

Reasoning behind the width and shoulder arrangement was as follows: Loaded trucks would be traveling the south side headed for the mill. They would be required to stay on the mixed portion and not travel the 3-ft shoulder. Empty trucks traveling on the north side would be permitted to run the penetrated 7-ft shoulder when passing loaded trucks, if

L. M. KRUPP is an Engineer with Isbell Construction Co., Wellpinit, Wash. Pacific Northwest Regional Conference, Spokane, April 1958.



necessary. Thus, 30 ft of mixed asphalt mat was to be sufficient for 95 pct of the traffic, and 10 ft of shoulder would be protected by the penetration.

Excavation work began in June 1953. Some 283,000 tons of rock were drilled, blasted, and moved to fill areas. An equal amount of pit run waste was also used in the fills close to the pit areas. The road was brought to 6 in. below final grade with local material, loaded and placed with scrapers. This finer material served as a seal for the large rock in the fills. This initial work was completed in the summer of 1954. The road was then opened to pickups, water and service trucks, empty pit trucks, Caterpillar tractors, and Euclid FFD trucks hauling about 71,000 tons of ore.

Since many small drainage basins were blocked by the fills, metal culverts were installed high on the fills. This placement permitted considerable savings on pipe. Normal run-off passed through these fills below the culverts since the lower fill material was large rock averaging 3 to 4 ft in size, with negligible fines. The culverts handled water during heavier rains, and gentle dips were strategically placed to handle flash floods.

In June 1955 the road was again brought to within 6 in. of final grade with local material placed by scrapers. Care was taken to avoid clay or *caliche* (a calcium carbonate material from which adobe bricks are made). Once caliche becomes wet and is covered, it will never dry out, always remaining plastic.

A 200-tph crusher was set up about a quarter-mile from the road near the midpoint. Alaskite, as collected in a stream bottom, was used as feed and was reduced to 1-in. max size—⅜-in. chips were screened out. Remaining material was as follows:

Screen	Average Sieve Analysis, Percent Passed	Arizona Specifications, Percent Passed
1 in.	100.0	100.0
3 mesh	65.1	50 to 65
20 mesh	38.7	(not required)
100 mesh	9.0	3 to 12

Density of the combined material was 138 lb per cu ft compacted and 110 lb per cu ft loose. The 1-in. gravel was placed in two layers, 3 in. deep and 40 ft wide. The first layer was watered and then compacted by a pneumatic roller. A small amount of ore was then hauled over the road to further aid compaction. The second layer was spread for uniformity, and then a 30-ft width, 2½-in. deep was windrowed to be mixed with asphalt. A Barber-Greene model 848 traveling mixer was used on a 7.5 cu ft windrow to mix 4.5 pct by wt of SC-4 oil. The mix was laid with a Caterpillar model 12 Motor Patrol, and compacted with a pneumatic roller to a 2½-in min thickness of asphalt mat. The ⅜-in. chips were then applied over .35 gal per sq yd of asphalt emulsion seal coat. The shoulders were prepared and penetrated with 0.5 gal per sq yd of SC-2 oil, with two passes on successive days—0.3 gal on the first pass, and 0.2 gal on the second. The road was opened to all traffic, except during laying of the asphalt mat.

A 900-ft length of asphalt mat, starting at the mill end of the road, gave considerable trouble. Unlike the remainder of the road, this section was on dirt and clay and after about three weeks of heavy use, it became soft and spongy, showing tire trucks and even heel marks when a man walked on it. The surface did not crack, but became wavy.

The entire 30-ft wide 900-ft long section was ripped up. The oil mat was found to be over-rich, running 5.5 pct to 6 pct oil, and the subgrade was damp. After the subgrade was ripped up, dried, and relaid, a Seaman Rotatiller mixer was run on the windrowed asphalt cake for pulverization. A small amount of gravel and MC-2 asphalt were added to the windrow. This was thoroughly mixed, re-laid, sealed and chipped and no further difficulties were encountered.

After two months of use, a total of about 200 sq yd of asphalt mat in six areas needed repair, apparently due to subgrade failure. In repairing these areas, caliche was removed and replaced with gravel, and the asphalt mat was patched with mix from a stockpile.

The loaded side of the road became very smooth and hard, while the empty return side turned rough and wavy. Traffic was reversed to put the heavy loads on the other side and this brought some life back into the road. It was indicated that the loads should have been reversed sooner and oftener when the road was new. On most highways, weight and wear are evenly distributed except in the center which will sometimes deteriorate from lack of travel.

Isbell Construction Company completed its stripping and mining contract at the end of March 1957 and Asarco assumed control of the mining operation. Up-to-date information on use of the El Tiro road was obtained from Mr. Don Purvis, superintendent for Asarco at Silver Bell. Asarco reports that total tonnage hauled up to March 1, 1958, was 1.9 million tons. Of this amount, Isbell hauled 1.1 million tons and Asarco hauled 800,000 tons.

Asarco is using Kenworth model 803 two-axle rear dump trucks of 38-ton capacity. Rear-axle loading is 100,000 lb and front axle 50,000 lb, thus placing 25,000 lb on each of the six tires. All tires are the same size: 18:00 x 33, tubeless, and inflated to a cold pressure of 85 psi.

Of several repairs made by Asarco the largest was one of full width for a distance of 150 ft. All failures were found to be due to clay or caliche in the area just below the 6-in. gravel subgrade. This caliche was local material brought in by the scrapers and had not been carefully selected.

Additional surface treatment included another coat of ⅜-in. chips, and two coats of sand to stop oil *bleeding*.

Comments: D. Purvis, Asarco: The road has given satisfactory service, and we believe will result in a savings in haulage costs for the life of the El Tiro orebody. The two-axle trucks severely *washboard* a dirt road, but so far have not had this effect on the oil surface of the El Tiro road.

C. V. Isbell, president, Isbell Construction Co., believes the continuous *kneading* action of the heavily-loaded rubber tires tends to keep the asphalt mat *alive*.

CONCLUSION

If present highway construction methods were planned along the lines of the El Tiro road, with similar selection of materials, intense compaction of fills, and overall control of construction in general, load limits could be considerably increased.

Perhaps other mining operations would benefit from a road of this type. Perhaps even some would-be mining operation, previously thought impractical because of haulage problems, would become commercial through the use of such a haulage roadway.

LINEAMENT TECTONICS AND SOME ORE DISTRICTS OF THE SOUTHWEST

This study examines the structural framework of the Southwest for evidence of the four principal trends of lineament tectonics. It attempts to classify their intersections and compares the positions of those trends that appear most favorable with the positions of the presently known mining districts.

by EVANS B. MAYO

This is a controversial topic. The author, in presenting his analysis, is aware that the study of lineament tectonics and relation of ore districts to regional structure is complicated by insufficient data and, unavoidably, by personal bias.

The development of lineament tectonics has been summarized by Umbgrove.[1] Early attempts to fit ore districts into the Cordilleran framework were made by Billingsley and Locke,[2,3] who do not refer to lineament tectonics, although their approach is similar; they observe that heat and fluids, including the ore-depositing fluids, are most likely to rise at or near intersections of major structures where the crust is fractured, or weakened, to great depth.

As a result of studies distributed over the earth—including ocean basins as well as continents—some tectonists recognize four dominant structural trends: 1) northwest; 2) northeast; 3) nearly east-west, or equatorial; and 4) nearly north-south, or meridional. Baker[4] proposed a theory to account for these trends and Sonder[5] called their world-wide arrangement the regmatic shear pattern. Moody and Hill[6] proposed a much more complicated shear network which, although fascinating and perhaps ultimately useful, will not be followed here. In a recent review of deformation within the Cordillera, Wisser[7] mentioned the four fundamental directions.

The fact that many geologists deny the existence of the regmatic shear pattern implies that the fundamental structures are far from obvious. It may mean, also, that some geologists are not accustomed to examine regional and world maps analytically. The maps require much study, and certain features should be isolated on overlays. Even so, with the present limited knowledge, uncertainties remain. The following analysis is a qualitative experiment, subject to change as information accumulates, and should be supplemented by the western sheet of the Tectonic Map of the United States.[8]

E. B. MAYO is Professor of Geology, University of Arizona, Tucson, Ariz. TP 4776 I. Manuscript, April 8, 1958. New York Meeting, February 1958.

LINEAMENT FRAMEWORK, SOUTHWESTERN U.S.

Many have probably gained the impression that the Cordillera of the West is oriented northwest-southeast and from this, unless experience rules otherwise, it is natural to assume that the structure likewise trends northwest-southeast. To an important extent this is true, yet anyone tracing off the western sheet of the Tectonic Map all the recorded northwest-southeast structures may be surprised to see what a small part of the entire area they occupy. In southwestern U. S. (Fig. 1) the northwest-southeast structures are mostly restricted to the eastern, southern, and western parts. The eastern margin of the Cordillera from northern Colorado to the International Boundary near El Paso, Tex., is obviously determined by some structure other than northwesterly ones. In eastern Nevada and far southward toward the Gulf of California many mountain ranges, valleys, and faults are meridional. In the Rocky Mts. of Colorado, and at many places in southern Arizona, the crystalline Pre-Cambrian is foliated northeast-southwest. The Uinta Mts. of Utah trend approximately east-west, in much the same way as a broad belt of transverse, west-northwest structures—the Texas lineament of Hill[9,9] and Ransome[10] in southern Arizona, southwestern New Mexico, and southern California.

It seems, then that there are four regmatic shear directions in the Southwest, but at many places they are discontinuous, and their projections must be inferred. To clarify these trends the four sets have been isolated into two systems: 1) northwest-northeast and 2) east-west-north-south (Figs. 2 and 3).

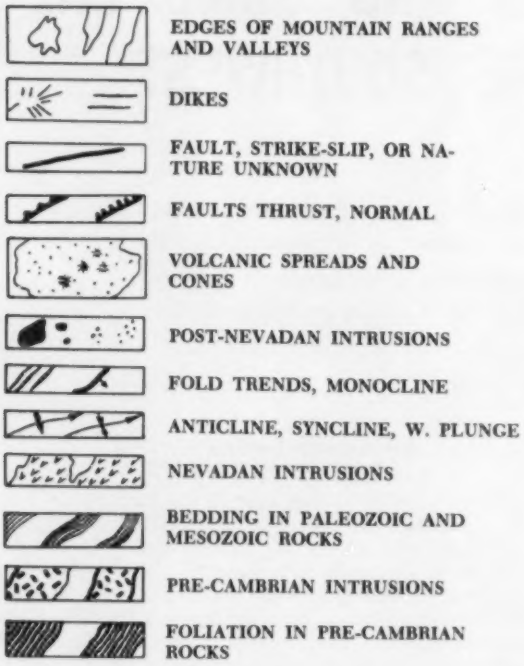
Northwest-Northeast System: A number of prominent northwest-trending zones of structure are easily recognized. They are designated by circled Roman numerals, the northeast-trending structures by circled capital letters.

Perhaps no two geologists would agree completely on the positions of all these belts. Names given below are for convenience only, and may be discarded where other names have priority.

(I) The Sierra Nevada-Lower California belt contains the Jurassic-Cretaceous granitic massifs of the Sierra Nevada and Lower California. These

The Transactions papers appearing in MINING ENGINEERING during 1958 will subsequently appear in AIME Transactions Vol. 211, and may be permanently referenced to that volume.

EXPLANATION OF STRUCTURE SYMBOLS



Symbols used on Figs. 1-3

crystalline masses form a barrier between the Pacific coastal region, dominated by northwest trends, and the interior where other structural trends are prominent.

(II) The Walker zone seems to extend from the northern end of the Sierra Nevada, southeastward into northwestern Sonora. Billingsley and Locke,[8] who proposed the name *Walker line*, suggested that this zone curved into southeastern Arizona. It is believed, however, that the line they defined includes several different structural belts.

(III) The southwest Arizona belt is parallel to the Walker zone and reaches from the Patagonia and Santa Rita Mts. of southern Arizona northwestward into southern Nevada.

(IV) The central Arizona belt extends northwestward from the Chiricahua and Mule mountains of southeastern Arizona to the San Francisco volcanic field.

(V) The southwestern New Mexico belt reaches from the International Boundary near Columbus, N. M., toward the Grand Canyon in Arizona. This belt is obscure in the Datil volcanic field and Colorado Plateau and possibly does not cross these features.

(VI) The New Mexico-Utah zone extends from the Guadalupe Mts. in trans-Pecos Texas and New Mexico, past Mt. Taylor, through the high Plateaus volcanic field to the Gold Hill district in Utah. The continuity of this zone, although locally interrupted, seems obvious.

(VII) The southwestern Colorado zone, beginning west of Tucumcari, N. M., extends past Taos and along the southwest side of the San Juan volcanic field and beyond to Bingham, Utah.

(VIII) The central Colorado belt begins in the area of the Spanish Peaks in southern Colorado and trends through Leadville and Climax toward the Washakie Basin in southern Wyoming.

(XI) The Laramie zone trends acutely across the Front Range of Colorado and along the western side of the Laramie Basin, Wyoming.

The following zones appear to be complementary to the above northwesterly trends:

(A) The northeast-trending Santa Rita belt is vaguely shown by faults, aligned intrusions, and the southeastern margin of the Datil volcanic field. It begins southwest of Bisbee, Ariz., and reaches past Tyrone and Santa Rita, N. M., to the northern end of the Tularosa Basin.

(B) The Morenci belt is also vaguely defined and may not extend as far as indicated (Fig. 2). It passes through the Datil volcanic field, its course revealed by alignments of the San Agustin plain, New Mexico, and the modifications at the northwestern ends of valleys at Mogollon, N. M., and Morenci, Ariz. The extension of this zone east of the Rio Grande is marked by faults and by the northeast trend of foliation in Pre-Cambrian rocks.

(C) The Jemez zone, beginning with a southwest-trending trough in southern Colorado, passes through the Jemez caldera and the Mt. Taylor area and along the northwestern border of the Datil volcanic field. The existence of this zone in the Globe-Miami district is suggested by the alignment of post-Nevadan intrusions and other structural features. Between Globe and Ajo, the Jemez zone seems concealed by the overprint of the Texas lineament (1-1, Fig. 3) and other structures. It may extend across southern Arizona to the Pinacate volcanos of northwestern Sonora, and beyond to the little cluster of cones on the Pacific Coast.

Zones (A), (B), and (C) form a broad northeast-trending belt that includes most of the Datil volcanic field as well as many other volcanic features. The broad belt, therefore, seems to have been tectonically active in later geologic time.

South of zone (C) the eastern front of the Cordillera trends somewhat east of north, whereas north of zone (C) the trend is about north-south, or even a little west of north. In the Spanish Peaks region near zone (C), therefore, there is a definite turn in the Cordilleran front, and apparently zones (A), (B), and (C) have had some part in modifying the course of the border between the Great Plains and the Rocky Mts. The broad belt of zones (A), (B), and (C) is obviously of great importance in the regional structure; should it cross some equally important belt of structures, intersections of great interest would be expected.

(D) The Front Range zone is named for the Front Range porphyry belt of Colorado, which forms the eastern part of the zone. The zone appears to extend southwestward along the northwest edge of the San Juan volcanic field to the Carrizo Mts. in northeastern Arizona. It may continue farther, through the San Francisco volcanic field to the area of northeast-trending foliation in the Pre-Cambrian rocks east of the Colorado River.

(E) and (F), two northeast-trending zones, occupy essentially the position of the Wyoming lineament of Ransome (Ref. 10, p. 294). There may exist in the southwestern part of this Wyoming belt a

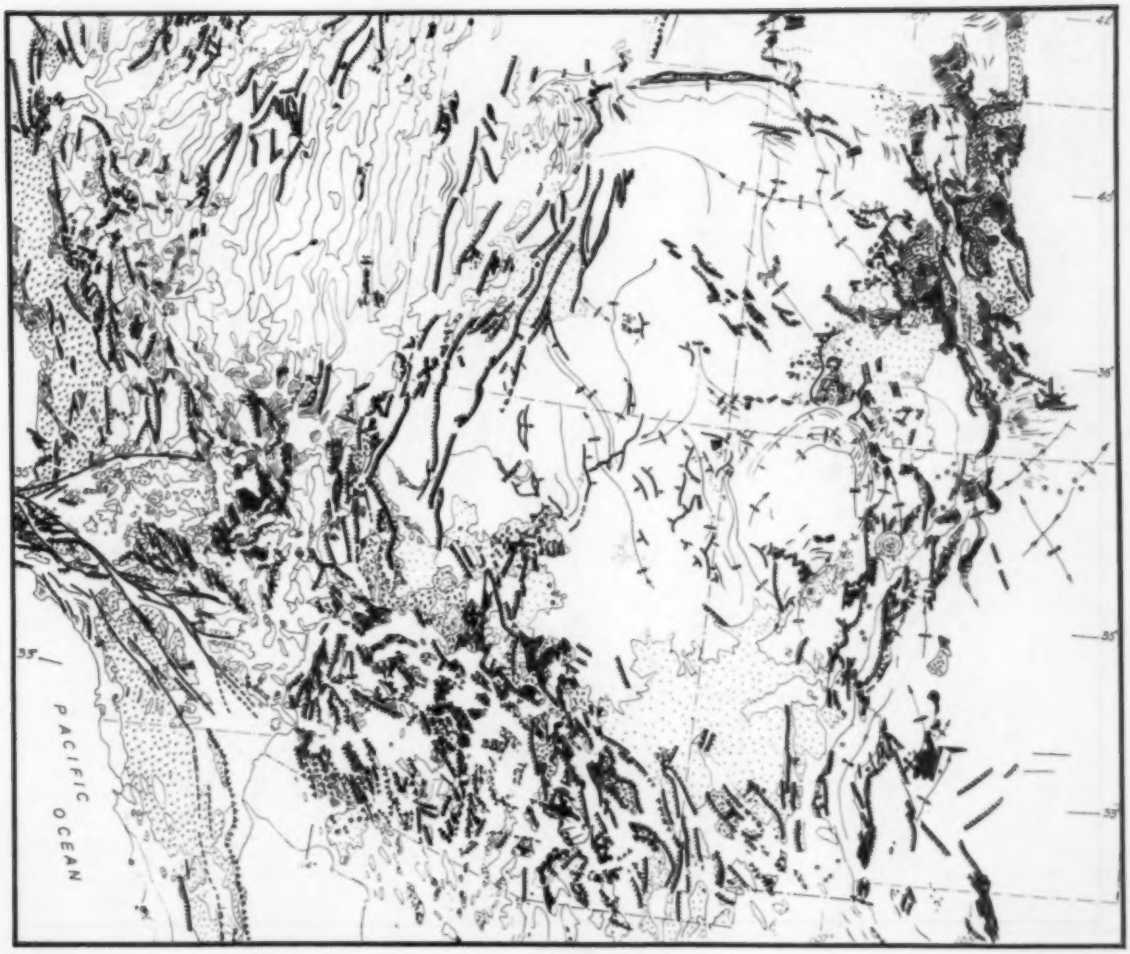


Fig. 1

very broad area of northeasterly trends, partly indicated by foliation in Pre-Cambrian rocks and partly by bedding trends in Paleozoic sediments. Traced northward out of Colorado, the Rocky Mt. ranges end in the northeastern part of this belt, in southern Wyoming. Broad passes intervene between these ranges and the more northern Rockies of Wyoming. The southwestern end of the belt is aimed toward the gap between the granitic massifs of the Sierra Nevada and Lower California.

(G) The southern Nevada zone is mostly shown by the trends of mountains and intervening valleys, and to a lesser extent by aligned intrusions. It should impinge on the eastern front of the Sierra Nevada between Lone Pine and Independence, Calif. Possibly this zone reaches northeastward to the vicinity of Bingham, Utah.

(H) The central Nevada zone is definitely indicated by aligned faults, yet exact position and orientation are uncertain. The structures seem to impinge on the Sierra Nevada in the Mammoth embayment, northwest of Bishop, Calif. This trend is considered largely responsible for the great reentrant in the Sierra front and may be partly responsible for the abrupt broadening of the granitic core southwest of the embayment.

(J) The Carson zone meets the Sierra front near Carson City, Nev. Toward the northeast the course of this belt of structures is suggested by the trends of valleys and mountains, by aligned intrusions, and by faults. To the southwest it may be the reason for some of the granitic prongs along the western edge of the Sierra Nevada batholith.

Although only two sets of lineaments have been examined, it already seems obvious that important geologic features are located at places where these two sets of trends cross. Some of these features, indicated in Fig. 2, are as follows:

1. (1) and (G, H, J), not exclusive—Sierra Nevada batholith.
2. (I) and (C,D,E,)—broadest part of the batholith of Lower California.
3. (II) and (C)—Pinacate volcanos.
4. (II) and (E,F)—large intrusions in Mohave Desert of California.
5. (II) and (G,H,J)—granitic intrusions east of Sierra Nevada.
6. (IV, V) and (D)—San Francisco volcanic field.
7. (V, VI) and (A,B,C)—Datil volcanic field and associated intrusions.
8. (VI) and (F)—High Plateaus volcanic field and intrusions.
9. (VII) and (C)—Jemez Caldera.
10. (VII) and (D)—San Juan volcanic field and intrusions.
11. (VII) and (G?)—Intrusions at and near Bingham, Utah.

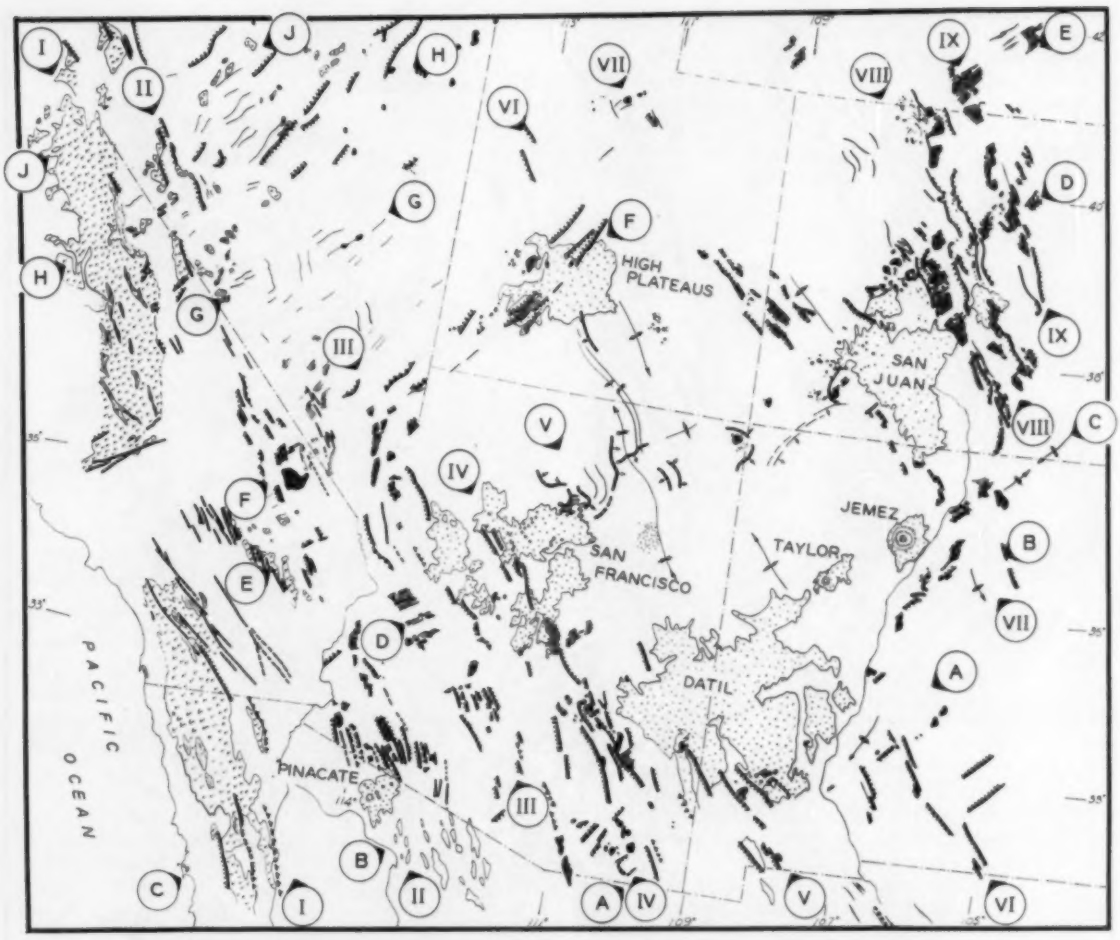


Fig. 2

12. (VIII) and (D)—large area of porphyry intrusions north of San Juan volcanic field, Colorado.
13. (VIII) and (E)—group of intrusions along Colorado-Wyoming border.
14. (IX) and (D)—Front Range porphyry belt, Colorado.

These examples suggest how intersecting weak zones in the crust may have localized the phenomena of intrusion and volcanism. The suggestion is further strengthened by consideration of the east-west-north-south lineament system.

East-West-North-South System: The structures belonging to this system are locally obvious, but in large areas they are either lacking or have not yet been mapped. This is particularly true of the east-west set. As a rule the two sets only approximately follow the east-west or north-south directions. The north-south set is usually oriented somewhat east of north, and the east-west set somewhat north of west. On the basis of information traced from the Tectonic Map,* there appear to be the following nearly east-west structures (Fig. 3):

(1) Texas lineament (with a possible branch, 1′). This great belt of transverse structures forms the southern border of the tectonic framework of the western U.S. In the region of Fig. 3, the Texas lineament is by far the most pronounced transverse belt. It can be traced from trans-Pecos Texas on the east to the Transverse Ranges of Southern California on the west. Strands within the belt, as in southern Arizona, are marked by nearly east-west faults and elongated or aligned intrusions. The entire zone, in southern Arizona, may be more than 150 miles wide.

(2) The San Francisco zone is not satisfactorily revealed by the assembled data. The best evidence for its existence is in eastern California and southern Nevada, where trends of intrusive contacts, elongated intrusions, west-northwest faults, and curves in thrusts and in the trend of bedding suggest a transverse disturbance. Some of the cones in the San Francisco volcanic field are arranged in transverse rows; possibly this trend extends into east-central New Mexico where foliation in Pre-Cambrian is oriented west-northwest. If this is the case, there are broad gaps with no evidence, and the supposed San Francisco zone is poorly defined. Perhaps it is valid only where supporting evidence has been mapped.

(3) The Spanish Peaks belt trends from southern Colorado past the San Juan volcanic field and into southern Utah. Groups of intrusions seem to continue this trend across Utah, and faults, intrusions and a belt of thrusts indicate its path across Nevada. This zone apparently reaches the Mother Lode of California near Plymouth.

(4) The Cripple Creek zone reaches from the southern end of the Front Range, Colorado, west-

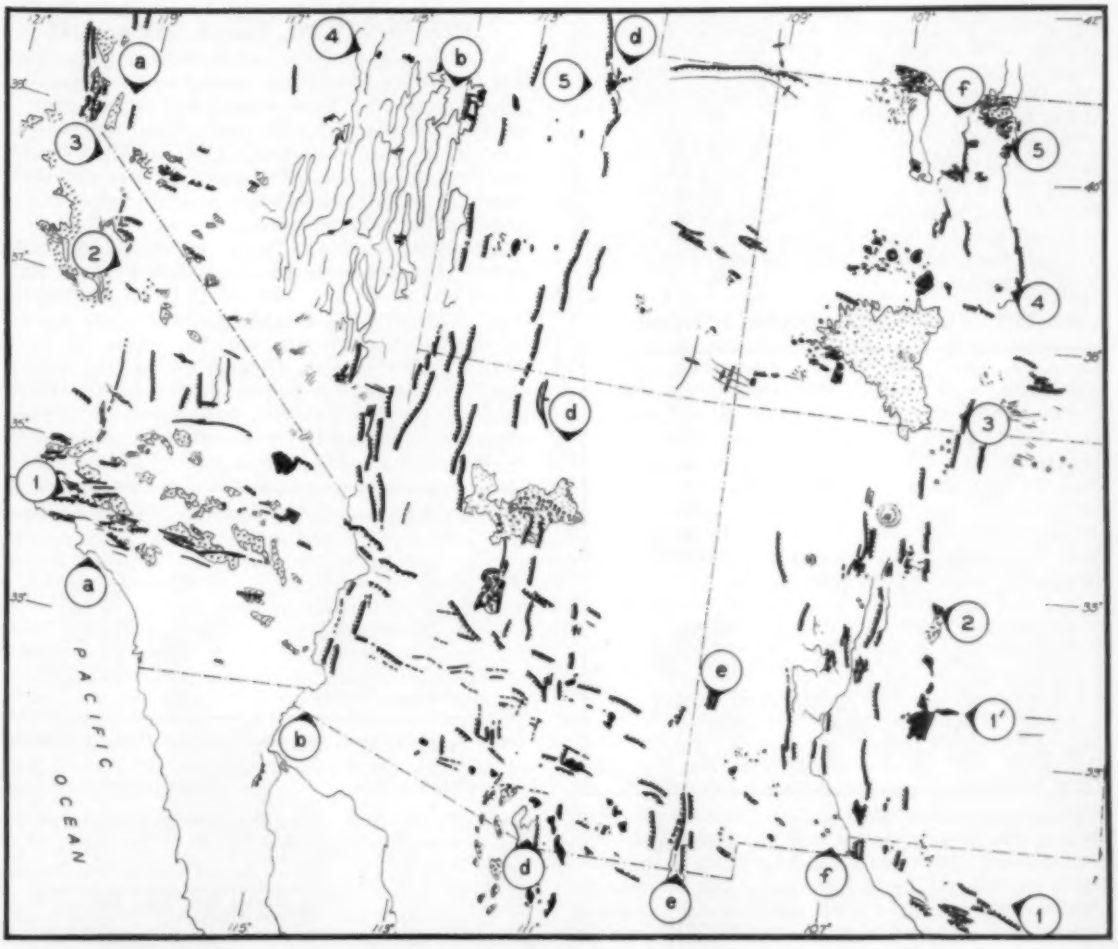


Fig. 3

ward to the great group of porphyry intrusions, and on into eastern Utah. This structure may extend across Utah to the Gold Hill district and westward into eastern Nevada.

There is some evidence (Fig. 3) in eastern Nevada that a transverse structure exists midway between zones (3) and (4).

(5) The Uinta belt begins in northern Colorado and follows along the Uinta axis to Bingham, Utah. Perhaps this is a branch structure, related to the Cripple Creek zone as (1′) is related to the Texas lineament.

Crossing the above structures are the nearly north-south lineaments, of which the following are recognizable:

(a) The Sierra Nevada belt is indicated at the north by north-south faults that at first merely border the Sierra, then slice obliquely into it and across it (e. g., Kern Canyon fault). Perhaps this meridional zone does not cross the Transverse Ranges of southern California.

(b) The Colorado River zone is very broad at the north, in eastern Nevada, and narrows southward along the Colorado River. It reaches the northern end of the Gulf of California.

(d) The Utah-Arizona belt trends north-south through central Utah and Arizona. In Utah and in northern Arizona it forms a boundary between the plateaus to the east and the Basin and Range province to the West.

(e) The Pelonicillo belt parallels the interstate boundary in southeastern Arizona and southwestern New Mexico.

(f) The Cordilleran Front belt, a very broad zone of meridional structures, parallels the eastern margin of the Rocky Mts. in Colorado and New Mexico.

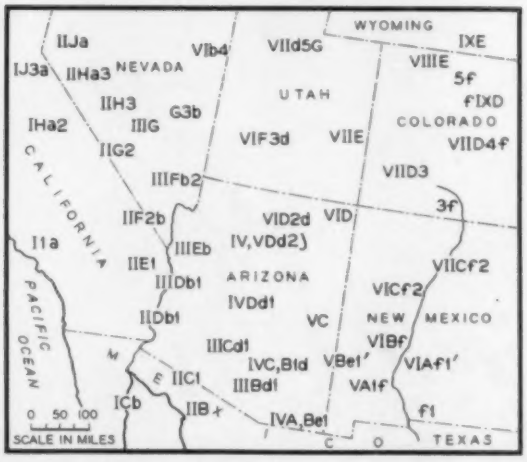
Comparison of Figs. 2 and 3 suggests that most if not all the 14 features listed above are localized not only on intersections of structures belonging to the northwest and northeast sets, but also on north-south-east-west crossings. For example, the Sierra Nevada batholith seems somewhat related to transverse zones (2) and (3) and to north-south zone (a), as well as to the structures already mentioned; the San Francisco volcanic field occupies the intersection of zones (2?) and (d); Datil volcanic field is on the northern margin of the Texas lineament where this is crossed by the north-south structures (e) and (f); the intrusions near Bingham, Utah, occupy the intersection of lineaments (5) and (d), and so on.

It has been noted that some of the structural trends are marked by aligned intrusions, and possibly these intrusions occupy minor intersections on the trends. If this is so, the evidence quite eludes the present analysis. It is otherwise, however, with cer-

tain groups of intrusions, with granite masses of regional dimensions, and with some of the most arresting volcanic phenomena. These features occupy the intersections indicated, or at least suggested, by data on the maps.

The above relation suggests that some of the major intersections, having been unusually weak places in the crust, were the sites of especially pronounced and long-continued igneous activity. This repeats Billingsley's and Locke's idea[11] that escape of heat and fluids is particularly favored on the structural intersections.

THE STRUCTURAL INTERSECTIONS



The *geologic crossroads* were located on a tracing (Fig. 4, above) first placed over Fig. 2, then over Fig. 3. There are many intersections, and it is disconcerting to realize that the entire region will be covered, provided the structural zones selected are numerous enough and broad enough. No doubt every place is an intersection of some kind, but this fact is of no aid in selecting areas of special geologic or economic interest, so it becomes necessary to establish guides to selection. This brief inquiry cannot approach a complete list of guides, but a few seem promising:

1. Crossings of the most pronounced structure belts—such as the Texas lineament and zones (A), (B), and (C)—should be of greatest interest.
2. The structural trends concerned should be fairly obvious, suggesting that the trends have been active in later geologic time.
3. More than two directions should meet at the intersection.
4. One or more of the directions should be accompanied by evidence of igneous activity.
5. Small or moderate-sized post-Nevadan intrusions should occupy the intersection, or:
6. If Nevadan granites of regional dimensions are present, the areas of interest should be marginal to the granite.

It is realized that areas of great importance from the viewpoint of exploration may be concealed and may therefore lack some or all of the above characteristics. This is of no importance in the present study, in which the objective is correlation with known ore districts.

With the guides listed above, selections can be made from the intersections in Fig. 4. These intersections are considered according to the transverse belts on which they are located.

INTERSECTIONS, TEXAS LINEAMENT

This broad, transverse belt is crossed by structures that follow the other three regmatic shear directions. Most important of these, apparently, is the northeast bundle of zones (A), (B), and (C). Next in order seem to be northwest zones (III), (IV), and (V); northeast zones (D), (E), and (F); and northwest zones (I) and (II). All the north-south belts reach or cross the Texas lineament.

Structural crossings were arranged into four classes. Intersections that involve the Texas lineament and zones (A), (B), or (C) and at least one other direction, and likewise have small or moderate-sized intrusions, are rated first class. An intersection involving four directions plus intrusions is also rated first class. If four directions are present but there are no intrusions, the intersection is second class, and if there are three directions plus intrusions but zones (A), (B), or (C) are not represented it

Table I. Intersections On and Near Texas Lineament

I	Ia	(2nd class)	II	El	(2nd class)
III	Eb	(3rd class)	III	Dbl	(2nd class)
II	Dbl	(2nd class)	I	Cb	(3rd class)
II	Cl	(1st class)	II	B	(4th class)
IV	DdI	(1st class)	III	Cdl	(2nd class)
III	Bdl	(1st class)	IV	C,Bld	(1st class)
V	C	(4th class)	IV	A,Be1	(1st class)
V	Be1'	(1st class)	VI	Bf	(2nd class)
V	Alf	(1st class)	VI	Af1'	(1st class)
	fl	(4th class)			

Table II. Lineament Intersections and Mining Districts

First Class Intersections		Mining Districts
II	Cl	Ajo
IV	Ddl	Jerome-Bradshaw-Bagdad
III	Bdl	Twin Buttes-Silver Bell
V	Be1'	Morenci-Mogollon
V	Alf	Santa Rita-Tyrone
VI	Af1'	Capitan iron—no important district known
IV	A,Be1	Bisbee-Tombstone-Courtland-Gleeson
IV	C,Bld	San Manuel, Ray, Miami, Superior, Globe, Mammoth, etc.
Second Class Intersections		**Mining Districts**
I	Ia	No important district known
II	El	Eagle Mountains, iron
II	Dbl	No important district known
III	Dbl	Artillery Mountains, manganese
III	Cdl	No district known
VI	Bf	Magdalena

Table III. Intersections On and Near Transverse Zone (2)

First Class Intersections		Mining Districts
I	Ha2	Southern end of Mother Lode on west; Bishop tungsten on east
VII	Cf2	Pecos
VI	Cf2	Mt. Taylor-Grants region, uranium
II	Fb2	Goodsprings-Searchlight, Nevada; Mountain Pass, California
VI	D2d	Monument No. 2—White Mesa
Second Class Intersections		**Mining Districts**
II	G2	Silver Peak-Goldfield-Rhyolite-Bullfrog
VI	D	Carrizo Mountains, uranium

Table IV. Intersections on Transverse Zones (3), (4) and (5)

First Class Intersections		Mining Districts
I	J3a	Mother Lode
II	Ha3	Aurora—Candelaria
VII	d5G	Bingham-Park City-Tintic, etc.
VI	F3d	Marysvale-Silver Reef-Iron Springs
VII	D3f	San Juan districts
VII	4Df	Cripple Creek
Second Class Intersections		**Mining Districts**
II	Ja	Virginia City (Comstock Lode)
II	H3	Tonopah
	G3d	Pioche
VI	b4	Gold Hill
	f IX D	Front Range Mineral Belt, Leadville, Climax

is second class. If three directions are present without intrusions the intersection is third class; if only two directions are represented it is fourth class. The localities and structural trends represented are shown in Fig. 4 and listed in Table I. The first and second class intersections only are listed, together with the associated mining districts, in Table II.

The contrast between the first and second class intersections is revealed in the relative number and importance of the *hits* scored in each class—seven out of eight in the first class, but no better than three out of six, and probably no major ore district, in the second class.

Intersections On and Near Transverse Zone (2): This vaguely defined, apparently weak or inactive zone compares very unfavorably with the Texas lineament, and its intersections have had to be classified somewhat differently. Where four trends cross and intrusions are present, the crossing is considered first class, but if intrusions are absent it is considered third class, even though important volcanic phenomena are present. Where two or three trends cross and intrusions are present the crossing is second class. All other cases are relegated to third or fourth class and eliminated. Locality VI Dd2 attains to first class because small, ultrabasic intrusions not shown on the map are present, whereas locality IV, V Dd2 is assigned to third class because the surface is mostly covered by volcanic rocks. Even so, uranium has been mined near Cameron, Ariz.

Few places in this transverse zone can be considered major ore districts. Most important, perhaps, are Bishop tungsten in California and Monument No. 2 in Arizona.

Intersections in Zones (3), (4), and (5): Parts of these zones are not satisfactorily revealed by the data on the Tectonic Map, but in general these structures are more obvious than transverse zone (2). It may be that over certain intervals, particularly in Utah and Nevada, the continuity of zones (3) and (4) will never be established. The first and second class intersections are listed in Table IV.

As selected above there are 19 first class intersections and 13 second class intersections. Ore districts are found on 18 of the first class, 10 of the second class. Furthermore, most—but not all—the major ore districts are on the first class crossings.

At first the correlation between intersections and ore districts seems remarkable—about 94 pct for the first class, 77 pct for the second. But these figures take no account of districts that were missed. Excepting some uranium-bearing areas, most of these are of lesser importance. If there is an additional transverse zone between zones (3) and (4), Ely and Eureka may occupy crossings on this zone.

The personal factor is, of course, a disturbing source of error. With all good intentions, the structural trends and their crossings were probably not selected without bias. In spite of many uncertainties, however, it is believed that a systematic relation does exist between the crossings of certain elements of the regional framework and the most important occurrences of ore.

IMPROVING CONTROL

Better maps will provide one answer to present imperfections in correlating ore faci with structure. Fortunately the maps continue to improve, and it should gradually become possible to deal more confidently with two-dimensional geometry. But two dimensions are not enough.

If hypogene ore has come from *below*, something must be known of conditions at depth, and probably the greater the depth the better. Three-dimensional control of ore is best disclosed by mine workings and natural sections. Billingsley and Locke in their second paper[2] offered a few examples, and many more are available. Whatever indirect knowledge is gained of the third dimension—beyond the depth of mines, drillholes, and erosion—must be won by the geophysicist.

Every geological problem, however, is four-dimensional, that is, it involves time. The structural history of any region under investigation holds the answer to the relative importance of various structural trends. Which structures were the longest active and when were they active? Where were the sedimentary basins of the past and when were they deformed? What was the sequence of intrusion, extrusion, differentiation,[10] and alteration? These features have been discussed and shown on maps, but the writer knows of no regional study involving all of them. If such complete data were available the mineral districts might be fitted into the regional framework like jewels into their settings. In that case a proper setting without its jewel would be subject to the most earnest inquiry.

This generalized account can only suggest a direction for further work. Obviously, regional structure is the essential framework for all geological studies, including investigations of ore deposits. It seems, then, that the methods and theory of lineament tectonics should be important in future explorations for economic minerals. The structural framework of the Southwest may prove to be different in many respects from the one proposed here, yet that framework should become more obvious as information accumulates. As the framework becomes more definite it should clarify the positions of known ore districts, reveal localities where new ore might reasonably be searched for, and outline those places where exploration would probably be wasted.

This article was written at the invitation of W. C. Lacy, who generously aided in its preparation. Although the author is acquainted with the geology of parts of the region discussed, the material presented here is mostly compilation. The American Association of Petroleum Geologists kindly granted permission to use information shown on part of the Tectonic Map of the United States.[6] Information was taken, also, from Vincent Kelley's tectonic map of the Colorado Plateau.[12]

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Discussion of this article sent (2 copies) to AIME before Dec. 31, 1958, will be published in MINING ENGINEERING.

U. S. GOVERNMENT SUPPORT TO MINERAL INDUSTRIES OF LATIN AMERICA

by SUMNER M. ANDERSON

Any discussion of outside support to Latin American mineral industries must concede at once the pre-eminent role of U. S. industry and business. American capital has developed the great copper resources of Chile and Peru, the lead-zinc of Peru and Mexico, the bauxite of Surinam and Jamaica, the petroleum and iron ore of Venezuela. American consumers have provided the market for their products. U. S. companies operating south of the border have trained Latin American geologists, engineers, chemists, and skilled labor—including metal, mineral, and fuel technicians—to new and greater competence.

The industrial demands of World War II drastically altered world economics and concepts of U. S. foreign mineral requirements. In this country discovery of vital mineral resources fell far behind the alarming depletion rates, and there was new appreciation of the actual and potential importance of the world's less extensively explored areas. During the war and afterward, the task of supplying the nation's mineral requirements became greater than private industry could carry alone, and the Government assumed a position of continuing support.

In Latin America, as elsewhere, this support applies in three categories: banking, procurement, and technical assistance. The first two are now generally accepted as necessary Government functions; the third has often been misunderstood and misinterpreted, although it has given rise to legitimate controversy. There have been major accomplishments in all three categories, as well as some errors of judgment.

Since the beginning of World War II, U. S. Government financing, procurement, and technical assistance have been applied on a large scale to a wide range of commodities and services throughout the free world. The present discussion—under the separate headings mentioned—will concern only the support related to a single industrial group in a single geographic area.

S. M. ANDERSON, Member AIME, is Chief Latin American Specialist, Division of Foreign Activities, U. S. Bureau of Mines, Washington, D. C. TP 4730A. Manuscript, May 16, 1957. New Orleans Meeting, February 1957. Updated by author to June 30, 1958.

FINANCING FOREIGN MINERAL PROJECTS

During the War Federal banking was conducted on an emergency scale by temporary agencies created to meet the abnormal circumstances. Unfortunately, there are no readily available data on these activities that would permit evaluating loans and credits extended for mineral projects in Latin America. The only agency operating in this field since World War II is the Export-Import Bank, under its own authority and to some extent from credits authorized by the Office of Defense Mobilization. The Bank can offer more capital—on more favorable terms—than is available from most Latin American banks, and its staff of engineers evidently can appraise loan applications more favorably than commercial banks in this country are willing to do. The risks seem to be justified, as defaults have been well under 1 pct of total loans.

From V-J day 1945 to the end of 1957, mineral loans to Latin America have been authorized for projects totaling $541.63 million in eight countries. In order of magnitude of credits, they have been made to Brazil, Peru, Chile, Mexico, Argentina, Venezuela, Guatemala, and Bolivia. In order of magnitude by industries, they are for development and expansion of steel mills, copper, manganese, nitrate plants, iron ore, zinc plants, sulfur plants, cement plants, tungsten, coal, and lead.

Loan Distribution: By far the largest loans have been $307.9 million for iron and steel projects in Brazil, Chile, Mexico, Argentina, and Peru; $100.4 for developing the great low-grade copper deposits of southern Peru; and $55.3 million for developing manganese deposits in the Territory of Amapa, Brazil. Others range from $20.8 million for a zinc smelter in central Peru to $19 thousand for iron-mine trucking equipment in Chile. It has been noted that 59 pct of the loans have been to foreign companies, 14 pct to companies of mixed foreign and American capital, and 27 pct to American mining companies. About 40 pct of the total authorizations has been disbursed so far.

In addition to these amounts, the Strategic Materials Division of the Economic Cooperation Admin-

"All aspects of this aid are based on the belief that U. S. freedom, military and industrial strength, and prosperity cannot be preserved in isolation from the rest of the world and that the nation's continued progress and security are inseparably integrated with the economic growth of the Western Hemisphere."

istration agreed in 1950 to advance up to $5.963 million in Marshall Plan funds and 1.8 million from ECA counterpart funds in Britain to develop extensive bauxite resources in Jamaica, with repayment over a period of 20 years in aluminum ingot for the National Strategic Stockpile. French and Netherlands possessions in the Latin American area were also eligible to receive loans from this source.

World Bank and Subsidiary: The Export-Import Bank performs only the functions of a bank. However, the International Bank for Reconstruction and Development—a U. N. institution better known as the World Bank—has recently established an organization that can not only lend money but can also participate in management on a shareholder or partnership basis. This new subsidiary, called the International Finance Corp., has been capitalized with approximately $100 million by more than 30 member nations of the World Bank. Private industrial projects will be considered for either IFC financing or participating loans from private investors in member nations, or both, with expectation of increasing the international flow of capital. Financing in the mineral field will be confined initially to projects in metal and mineral processing but eventually may be extended to mining. As a participating member, the U. S. Government has contributed $35,168,000, or 35 pct of the organization's capital.

Investment Insurance: The International Cooperation Administration has made some foreign loans, but none to American mineral projects. However, to encourage new American investment abroad that will promote the purposes of the Mutual Security Act the ICA, acting through the Export-Import Bank, has offered two types of investment insurance since Oct. 15, 1954, each at a cost to the insured of 0.5 pct per year of the face amount of the contract. One type insures the investor against inability to convert into dollars the capital invested in a foreign country and the earnings derived from this capital. The other insures the investor for a specified maximum amount against expropriation or confiscation of property.

As of mid-1958, a single guarantee of $3 million against expropriation had been written on new mineral investments in Bolivia,* but several million dollars' worth of applications from Latin America were pending. At present both types of insurance are available for investments in Bolivia, Costa Rica, Cuba, Equador, Guatemala, Haiti, Honduras, Paraguay, the British West Indies and British Guiana, the French West Indies and French Guiana, and the Netherlands Antilles and Surinam; convertibility insurance only is available in Colombia and Peru. Those interested in applying for investment insurance may obtain further details by writing the Investment Guaranties Branch, International Cooperation Administration, Washington 25, D. C.

PROCUREMENT

Federal procurement is a business conducted to provide materials and equipment essential to normal Government operations and—on a larger scale—the defense and security of this country and the free world. The function of security includes purchase of reserve stocks of strategic minerals and other raw materials. Procurement is not designed or ordinarily administered to benefit the foreign supplier of material; nevertheless, the seller, his community, and the country where he operates prosper and are strengthened in accordance with the economic laws of business in a capitalistic system. Thus procurement of minerals from foreign sources is not aid in the usual sense of the word, but the type of support that any business supplier receives from his customers. Latin America is the largest foreign provider of essential minerals to the U. S. and consequently the chief recipient of mineral-bought dollars and their equivalent in American goods. Of course the suppliers individually determine the extent to which their profits are used for further mineral development.

Before World War II authority for Federal purchasing was vested in the Treasury Department's Procurement Division. But the start of World War II began an unprecedented demand for arming the nation and its allies, and from 1940 to the present,

* A gold-dredging operation of South American Placers Inc., wholly-owned subsidiary of South American Gold & Platinum Co.

purchasing authority has been disbursed and reconsolidated through a succession of special-purpose agencies. Certain types of purchases today are controlled by the AEC, but the bulk of metal and mineral purchasing for the minimum and long-term objectives of the military stockpile and for the supplemental stockpile is the delegated responsibilty of the Defense Materials Service of the General Services Administration. However, some of these supplies are augmented through procurement services of other agencies, such as the International Cooperation Administration, which buys with counterpart funds, and the Commodity Credit Corp., which barters with surplus agricultural products.

It is difficult to ascertain how much the Federal Government has spent, during or since World War II, for ores, concentrates, metals, and minerals from Latin America—to say nothing of crude petroleum and petroleum products, which are not stockpile items. Probably these purchases are in the low billions of dollars.

In a few items purchase contracts alone have not been enough to insure adequate flow of supply. For this reason the Defense Plant Corp., a warborn subsidiary of the Reconstruction Finance Corp., was created to put the U. S. Government in the production business. Initial authorizations in 1942 to invest $4 million for vanadium-production facilities in Peru and $5 million for copper-production facilities in Chile involved the Government in management control during the war period only, but two other ventures have lasted much longer—the Longhorn tin smelter and the Nicaro nickel project.

Tin Smelter Project: Construction of the Longhorn tin smelter at Texas City was begun in October 1941 by Ford, Bacon & Davis, in accordance with plans designed by the Tin Processing Corp., subsidiary of the Billiton Co. Production started in April 1942 and continued under Government contract through 1956. Initial cost of building the smelter was about $6.3 million, but investment in property, plant, and equipment had reached $13.059 million by mid-1956, when the net value, after deduction for depreciation, was listed at $5.445 million. The plant was sold Jan. 3, 1957, by the Federal Facilities Corp. of the Treasury Department* to the Wah Chang Corp. for $1.35 million, plus $2 million contingent on certain defined results of operation.

Billiton Co. believes the smelter cannot compete successfully with tin smelters operating elsewhere in the world, partly because of higher labor costs. The accounting procedures used by the Government report an average operating loss of $721,000 a year for the six-year period since 1950, but a responsible official of the Federal Facilities Corp. has stated that the entire Government tin program, which involved marketing transactions in addition to smelter operation, was conducted without financial loss to the Government. In any event, the purpose of insuring a continuous flow of tin to this country during the war and until the stockpile objectives were reached was realized. During its 15 years of operation the smelter produced 447,312 long tons of refined tin from about 970,000 tons of concentrate—practically all the tin concentrate imported into the U. S. Smelter receipts from Bolivia amounted to about 741,000 long tons of concentrate containing 273,400 tons or 36.9 pct Sn. This concentrate had to be blended with 71.9 pct concentrates from other sources—chiefly Indonesia, Thailand, and the Belgian Congo—to make high-quality tin.

The effect on Bolivia's economy was perhaps an exception to the rule of beneficial support. Although the purchase program substantially subsidized Bolivian small and medium-scale producers of substandard concentrates and prolonged their industrial existence, it is doubtful that any general improvement in the country's economic condition has resulted since the revolution of April 1952.

Nicaro Nickel Project: The other Defense Plant Corp. venture that survived the war is the Nicaro nickel plant on Levisa Bay, Oriente Province, Cuba. In rounded figures capital investment, starting in 1942 with $19.3 million, reached $31.7 million by 1949, when it was taken over by the GSA. Under that agency $56.6 million has been added, and by June 30, 1958, investment totaled $88.3 million, before amortization and depletion amounting to $17.8 million. The plant was operated between December 1943 and March 1947 on a fee basis by Nicaro Nickel Co., subsidiary of Freeport Sulphur, with funds supplied by the Reconstruction Finance Corp. Freeport Sulphur Co. owns or controls much of the deposits supplying the ore.

The plant was idle from April 1, 1947, to Jan. 30, 1952, and was transferred first to the War Assets Administration and later to the GSA, after that organization had been established by law in mid-1949 as a permanent management agency of Government property and records.

When the Korean War again created a nickel shortage, resumption of Nicaro's operations became a factor of national security. The plant was rehabilitated on contract by the Frederick Share Corp., which had constructed it, and since Jan. 31, 1952, it has been operated on a fee basis by the Nickel Processing Corp., of which National Lead Co. owns 60 pct and Fomento de Minerales Cubanos S. A., 40 pct. As of June 30, 1958, nine years and ten months of total operation have produced approximately 134,000 short tons of nickel, plus cobalt in 168,000 tons of oxide derived from some 109 million dry short tons of ore containing 1.38 pct Ni.

The plant is reported to have operated without Government subsidy or loss to the taxpayers since 1952. Established at a time when private enterprise could not be induced to venture capital in this commercially untested process, it has added substantially to the National Stockpile and has brought an important, growing industry to Cuba. Now that the plant has proved successful the Government, following its usual policy, hopes to sell or lease it to private industry.

TECHNICAL ASSISTANCE

Technical assistance in minerals for Latin American programs consists largely of teaching, training, and exchange and development of information. It provides only the supplies and equipment necessary for effective education. Usually technical assistance programs do not supply capital for economic development, but attempt to create or improve conditions and local skills that will encourage private investment.

The field of mineral resources is only one area in which technical assistance is offered—there are programs for agriculture, industry, transportation,

* To which control had passed when the Reconstruction Finance Corp. was liquidated in 1954.

Table I. Export-Import Bank Loans* Authorized (Less Cancellations and Expirations) to Metal and Mineral Development Projects in Latin America, Sept. 2, 1945 to Dec. 31, 1957

Metals and Minerals	Thousands of Dollars								
	Total, Latin America	Argentina	Bolivia	Brazil	Chile	Guatemala	Mexico	Peru	Venezuela
Ferrous Metals									
Iron ore	26,043	—	—	12,274	2,769	—	—	11,000	—
Iron and steel mills	281,858	60,000	—	68,279	77,550	—	76,029	—	—
Manganese**	57,885	—	—	55,341	1,180	—	745	649	—
Tungsten ore	3,363	3,000	363	—	—	—	—	—	—
Total	369,149								
Nonferrous Metals									
Copper***	101,239	—	—	—	800	—	—	100,439	—
Lead ore	500	—	—	—	—	500	—	—	—
Zinc plants	21,138	—	—	—	—	—	338	20,800	—
Total	122,877								
Nonmetallic minerals									
Cement plants	6,358	—	—	3,066	—	—	290	—	3,012
Nitrate plants	29,090	—	—	—	27,851	1,239	—	—	—
Sulfur plants	11,414	2,000	—	—	—	—	9,414	—	—
Total	46,862								
Fuels									
Coal	2,740	—	—	—	—	—	2,740	—	—
Total Metals and Minerals	541,628	65,000	363	138,960	110,120	1,739	89,556	132,888	3,012

Source: Compiled by Federal Bureau of Mines from Export-Import Bank of Washington semi-annual reports to Congress.
* Including credits from DPA funds ($16,634 thousand) and guarantees of loans from commercial banks ($691 thousand).
** To Brazil and Mexico for manganese ore development; to Chile for ferromanganese plant.
*** To Chile for copper wire plant; to Peru for copper ore mining.

health, education, labor, public administration, and community development. At present about 25 pct of all technical assistance funds is allocated to Latin America; 75 pct is divided among countries of the Near and Far East, Europe, and Africa. The U. S. spends about $1.5 million a year for Latin American mineral projects, or 4 pct of the Latin American technical cooperation expenditures.

All mineral projects are conducted by specialists of the sponsoring agency, working jointly with counterpart personnel of the host countries, along three general lines of procedure: 1) the specialist, by instruction and demonstration, directs the approach to problems presented by his hosts; 2) the specialist and his co-partners join in completing a project; 3) qualified candidates of the host countries are selected for specific periods of advanced training in the U. S.

Before, during, and for a short time after World War II technical assistance in various forms for Latin American mineral projects was sponsored or provided by the State Department's Interdepartmental Committee on Scientific and Cultural Relations and Institute of Inter-American Affairs and by subsidiary agencies of the Office of Emergency Management and the Reconstruction Finance Corp. For the past several years technical assistance has been the direct responsibility of both the UN and the AEC, and principally of the State Department's International Cooperation Administration and predecessor agencies.

Since 1950 the UN has administered a worldwide technical assistance program to which the U. S. contributes about $15 million a year, or 54 pct of the cost. It is estimated that not more than $100,000 of this goes to mineral projects in Latin America. The UN recruits staff and field specialists from all member countries, including those behind the Iron Curtain, and has occasionally borrowed from the U. S. Department of the Interior. It grants fellowships for professional training in any country that can supply the type of training desired.

Since 1951 the AEC has conducted projects varying from a month to several years' duration in Bolivia, Brazil, Colombia, Peru, and Venezuela. These projects include brief preliminary investigations of known and potential uranium areas; supply of technical reports on uranium geology, exploration, and ore recovery; and training of foreign scientists in those subjects in their own countries and the U. S. The AEC assigns specialists from its own staff and from the USGS to countries with which it makes independent agreements.

On June 5, 1950, President Truman signed the Act for International Development, making active foreign policy of the famous Point IV of his 1949 inaugural address, in which he stated: "The material resources which we can afford to use for the assistance of other people are limited. But our imponderable resources in technical knowledge are constantly growing and are inexhaustible. . . . Greater production is the key to peace. And the key to greater production is a wider and more vigorous application of modern scientific and technical knowledge."

Technical Assistance Program: On September 8, 1950, by Executive order, the Point IV Program became the primary responsibility of the Department of State, which brought together all fields of technical assistance, including the minerals field but excluding uranium, under the Technical Cooperation Administration newly created for that purpose. However, the U. S. Department of the Interior retained a share of technical control of the mineral program specialists assigned by its agencies. In 1953 the Technical Cooperation Administration was merged with other related agencies to become eventually the present International Cooperation Administration; the Point IV Program came to be known alternatively as the Technical Assistance Program, but the nonpartisan principles of the program were endorsed by President Eisenhower and continued without fundamental change. The International Cooperation Administration contracts for the services of American consultants and consulting firms and recruits specialists from private industry when this is practicable, but it more regularly retains, on special assignment, personnel supplied and technically administered by the U. S. Department of the Interior. During the fiscal year 1958 ICA expenditures for mineral projects in Latin America amounted to $591 thousand, distributed, in

Table II. Latin American Specialists Trained by U. S. Department of the Interior in Geology, Chemistry, Engineering, and Metallurgy, 1946 to June 30, 1958

From	By USGS	By USBM	Total
Middle America			
Cuba	1	3	4
Haiti	1	—	n 1
Mexico	29	13	42
Costa Rica	1	—	1
Total, Middle America	32	16	48
South America			
Argentina	4	—	4
Bolivia	3	—	3
Brazil	21	15	36
Chile	9	—	9
Colombia	5	4	9
Ecuador	1	—	1
Paraguay	1	—	1
Peru	6	9	15
Uruguay	—	1	1
Venezuela	2	—	2
Total, South America	52	29	81
Total Latin America	84	45	129

order of magnitude, to Brazil, Chile, Peru, Mexico, Cuba, Colombia, and British Guiana.

Semi-independently and under most of the shifting sponsorships and administrative ties summarized here, the U. S. Department of the Interior has been involved in technical cooperation with 14 Latin American countries, in addition to other foreign areas, continuously since 1940 through its Geological Survey, and since 1942 through both its Geological Survey and Bureau of Mines. The two agencies operate similarly in regard to their trainee programs, carefully screening candidates for advanced training in the U. S. These candidates must have had fundamental academic education in geology, chemistry, engineering, or metallurgy to qualify for specialized advanced study, usually of one year's duration, at Government laboratories and field stations throughout the U. S., and in some instances at American universities. More mature and fully trained professionals occupying positions of importance, such as the heads of foreign Government mineral agencies, receive "leader grants" of one to three months, visiting Government research stations and industrial operations in the U. S. to observe the latest techniques and practices of possible application to problems in their own countries.

Since 1946, when the trainee program started, the USGS and USBM have returned to responsible mineral positions in Latin America 129 trainees and leaders from 14 countries. This does not include the many foreign engineers, geologists, metallurgists, and chemists who are trained on the job with American field parties in their home countries.

Twelve years is a short period by which to evaluate a training program. Accomplishments have not been spectacular, but they have been steady and in some areas are showing signs of compounding with time. Definite progress has been made against the old Spanish tradition that physical work is degrading to a professional man.

Many Latin American countries are seriously short of candidates with the basic technical education to qualify for advanced training and equally short of technical schools offering adequate courses in mining engineering and earth sciences. The technical assistance cooperative program is being adjusted to improve this situation where possible. One of the most frustrating obstacles is that Government service offers small economic incentive in the upper brackets and none in the lower brackets, so that working hours must permit employes to make a living in private part-time employment. The situation will have to be corrected from within the countries themselves; Mexico and Venezuela are among those showing progress in this direction.

Role of U. S. Geological Survey: In field programs abroad the USGS and USBM pursue the same training objectives but operate independently of each other and by somewhat different methods. The USGS, in close cooperation with its counterpart agency in the host country, undertakes long-term mapping and reconnaissance projects or detailed geological study of specific areas and the simultaneous bilingual publication of results as official documents. Since 1942, 56 such studies have been published, documenting work in 15 countries. Fifty-one of these cover economic mineral resources of thirteen metals and seven industrial minerals, including ground water, and five are academic studies of volcanism and stratigraphy. All contribute to the knowledge of mineral resources and geological processes, to the competence of those engaged in their preparation, and to the effectiveness of national geological agencies. Some may have influenced the decision of investors in developing resources. The largest single project, still in progress, is the determination of iron ore reserves in the State of Minas Gerais, Brazil, which will assume world importance if and when transportation outlets to the coast are established. M. A. Hanna Co. is studying this problem in relation to the extensive holdings of the St. John del Rey Mining Co.

The USGS now has technical representation in Mexico, Brazil, Chile, and Peru. Past projects have also been conducted in British Guiana and in all the Latin American republics except Uruguay.

Role of U. S. Bureau of Mines: USBM specialists work in an advisory and instructional capacity with and through their counterpart agencies—which may be equivalent technical agencies, government-controlled operating organizations, or development banks—with less emphasis on full-time participation in integrated projects than on special phases of established operations. Results of such projects as the coal studies of southern Brazil have been reported in USBM publications, but most of these accomplishments do not lend themselves to constructive publication.

Metallurgists advise on establishment and operational improvement of Government metallurgical laboratories that serve the domestic mining industry. They also extend direct aid to small and medium-sized mineral operators on appropriate techniques of ore treatment, which often make the difference between marginal and profitable operations. Large-scale operators are entitled to this service but usually rely on their own technical staffs. Examples are too numerous and varied to list here, but one that is outstanding is the establishment in 1950 of Brazil's first profitable lead-refining industry by reducing from 8 days to 5 hr the process time for eliminating antimony.

Government development banks stimulate domestic mining ventures by making capital loans, and USBM mining engineers help the banks to evaluate investment risks and guide the applicants on efficient organization and operating procedure. These services are not restricted to loan applicants but apply also to projects endorsed by the counterpart agency to which the specialists are attached. In Colombia, USBM engineers are helping to expand

the national coal industry, and in Mexico they have inaugurated a badly needed health and safety program. The engineer assigned to Peru has successfully promoted the establishment of a department of metallurgy at the Universidad Nacional de Ingenieria in Lima, under joint sponsorship of the University, the governments of Peru and the U. S., and mining companies operating in Peru.

At present the USBM has representatives in Brazil, Colombia, Cuba, Mexico, and Peru. A project in Bolivia was terminated in 1951.

U. S. Department of the Interior expenditures for technical assistance before 1946 were nominal. From 1946 through 1950 they averaged $70,000 a year and from 1951 through 1958 about $200,000 a year, almost entirely from funds supplied by other agencies. Every representative sent on a foreign assignment, whether by the Geological Survey or the Bureau of Mines, is fully supported by the specialized facilities of his agency at home.

Occasionally the Bureau of Mines provides technical services by direct contract to foreign governments, which pay the total cost. The largest of these projects has been the successful development of an oil-shale treatment process in cooperation with the Brazilian Oil Shale Commission, which expanded its pilot plant at Taubate to semi-commercial operation, turned over in 1957 to Petroleo Brasileiro, S. A. (Petrobras).

CRITICISMS OF FOREIGN AID PROGRAM

The foreign aid program, of which technical assistance is only a part, rests on the fact that this country and other free nations are mutually dependent for their welfare and long-term security. Yet the most persistent criticism of foreign aid is the accusation that the program is a giveaway. The Bureau of Mines and the Geological Survey have not conducted their missions gratuitously. Latin America is contributing to joint technical assistance projects of all types at a ratio of $2.70 for every $1.00 from the U. S.

One unique diagnosis is noteworthy only because it was postulated by someone who was then executive secretary of the UN Economic Commission for Europe. In a speech delivered in December 1956 at the New School for Social Research, the Swedish economist, Gunnar Myrdal, said that foreign aid is extended to atone for practicing the selfish principles of ordinary business. He believes the U. N. should control expenditure of all U. S. foreign aid funds.

Latin American government leaders praise the quality of U. S. aid to countries in this hemisphere but commonly complain that expenditures have been a trickle compared with the total billions distributed since World War II. This must be conceded, but it ignores two highly pertinent facts: By far the greatest proportion of aid to Europe and Asia has been directed toward recovery from war devastation and building military defenses against the Soviet threat, while virtually all the aid to Latin America, which has been spared the necessity for that type of help, has been in the form of technical assistance and economic programs.

Segments of the American mining industry have suggested that their Federal Government is fostering the competition of foreign industries with American interests abroad, despite the traditional doctrine that private enterprise thrives under competition. Actually, in the field of small to medium operations, technical assistance has been concentrated on developing resources that American capital has ignored as being too small or of no investment interest for other reasons.

One example may be cited of the effect of Government support in the field of large operations. Regular mining of the Serra do Navio manganese ores, Territory of Amapa, Brazil, was formally inaugurated Jan. 5, 1957, at an annual shipping rate of 600,000 tons and capacity of 1 million tons. All three elements of U. S. Government support have contributed in developing this operation. Technical assistance collaborated in early examination and evaluation of the discovery; the Export-Import Bank lent $55.3 million in development capital; and the GSA secured the loan with a Government procurement agreement. The list of beneficiaries is long. The U. S. Government will profit by interest on the loan and assurance of a steady supply of ore for the stockpile. U. S. security will be strengthened by the easing of dependence on Eastern Hemisphere sources for manganese. Three companies will profit directly—the Brazilian Industria e Comerico de Minerios S. A.; Bethlehem Steel Co., co-owner and operator with the Brazilian company; and Foley Bros., the contractor for plant, railroad, and docking installations. The city of Macapa on the Amazon will become an important international port, and thousands of inhabitants of the Territory will enjoy a higher standard of living. At the port inauguration the manganese project was lauded by a Brazilian official as "an example of what may be done by national private initiative when aided by the Brazilian Government in collaboration with foreign financial and technical aid."

FUNDAMENTAL CONCEPTS

Banking and procurement are immediate economic assets to the U. S., and the annual interest on outstanding loans of the Export-Import Bank to Latin American mineral projects is far greater than the cost to the American taxpayer of Federal expenditures for technical assistance in the same area.

All aspects of this aid are based on the belief that U. S. freedom, military and industrial strength, and prosperity cannot be preserved in isolation from the rest of the world and that the nation's continued progress and security are inseparably integrated with the economic growth of the Western Hemisphere.

In promoting this growth, we are meeting sincere cooperation from professional and industrial people of the member nations. The same is not always true of their governments, many of which maintain barriers to capital investment in highly restrictive legislation, taxation, exchange controls, and the historically demonstrated threat of expropriation. But the outlook is hopeful. Progressive reforms have been adopted in several countries, and the tangible results in mineral industrial growth can not be ignored indefinitely by their neighbors. Acceptance of the continued role of Latin America solely as a source of raw materials for American conversion to finished goods is regarded as a serious underestimate of the future. Latin America has already started an industrial revolution that may well match, in the next fifty years, the growth pattern of this country during the past fifty. We contribute to that growth that we may continue to share its rewards.

Discussion of this article sent (2 copies) to AIME before Dec. 31, 1958, will be published in MINING ENGINEERING.

SCALE-UP RELATIONSHIPS IN SPODUMENE FLOTATION

Flotation feed was held constant for batch laboratory tests and continuous pilot and commercial plant tests on a spodumene ore to determine the relationship between flotation behavior and the size and type of flotation machine. Results showed that additional retention time would be needed in the plant flotation circuit to duplicate laboratory or pilot plant performance when operating variables of the plant flotation machines remained unchanged.

by W. E. HORST

During the past few years of operation at Kings Mountain, N. C., full-scale flotation has generally yielded poorer metallurgical results than those obtained in the laboratory or pilot plant. After 2 min in each size of Denver flotation machine in the spodumene rougher circuit, pilot recovery (41.7 pct) was almost three times that of the plant (13.6 pct) and about twice that of the laboratory (21.0 pct). Pilot and commercial plant data are based on continuous operation, and laboratory results on batch testing of rougher performance. The ore is a pegmatite containing spodumene, feldspar, quartz, mica, and amphibolite.

Data were accumulated to evaluate the scale-up relationships between laboratory, pilot plant, and plant flotation cells. Flotation rate constants and dimensional analysis were used to define the relationship existing between flotation behavior and scale of operation.

Measuring Flotation Rates: Efficiency of the rougher stage was measured by flotation rate, defined as the recovery that can be attained within a given time.*

* The problem of measuring flotation rates has been studied by many investigators, whose methods have varied. Published studies on flotation kinetics have been summarized recently by Gaudin.[1]

When comparing flotation rates, it is more satisfactory to compare straight line relationships between recovery and flotation time than exponential curves resulting from plotting cumulative recovery vs cumulative flotation time. To convert the exponential curves into straight line relationships, rate equations were applied similar to those used in chemical kinetics to study the velocity of chemical reactions.

Two rate equations have been used in this investigation to measure efficiency of the various cells:

1.5 Order Rate Equation

$$\frac{dR}{dt} = k(A-R)^{1.5} \qquad \text{[Eq. 1]}$$

Second Order Rate Equation

$$\frac{dR}{dt} = K(A-R)^{2} \qquad \text{[Eq. 2]}$$

Upon integration Eq. 1 becomes:

$$\frac{1}{(A-R)^{1/2}} = \frac{k}{2}t + \frac{1}{A^{1/2}} \qquad \text{[Eq. 3]}$$

and Eq 2 becomes:

$$\frac{1}{A-R} = Kt + \frac{1}{A}$$

or

$$\frac{t}{R} = \frac{1}{A^2K} + \frac{t}{A} \qquad \text{[Eq. 4]}$$

where R = cumulative recovery [percent recovery of total value (spodumene) in flotation feed].
A = initial concentration, pct (100 pct of mineral to be separated).
t = flotation time (minutes).
k = flotation rate constant for 1.5 order rate equation [units: 1/(percent) 0.5 (min)].
K = flotation rate constant for second order rate equation [units: 1/(percent)(min)].

W. E. HORST, Junior Member AIME, is Metallurgical Engineer for Foote Mineral Co., Research and Development Dept., Berwyn, Pa. TP 4779B. Manuscript, Nov. 7, 1957. Southeastern States Mining Conference, Tampa, Fla., October 1957.

Application of Dimensional Analysis: Use of dimensional analysis for a particular application is based on the assumption that certain variables are independent, and all others dependent or irrelevent. In the flotation process the following variables were assumed to be independent—flotation rate, length (measurement of flotation machine), impeller speed, horsepower, and pulp density. Other variables were assumed to be dependent or irrelevant. For example, capacity is dependent on flotation rate and aeration on impeller speed and horsepower.

The five independent variables can be expressed by a dimensionally homogeneous equation as follows:

$$f\,(K, L, N, H.P., \rho) = 0 \text{ where}$$

K = flotation rate constant (second order rate equation).
L = length, measurement of flotation machine.
N = impeller speed.
$H.P.$ = horsepower.
ρ = pulp density.

In accordance with Buckingham's theorem, the above equation can be reduced to the form:

$$f\left(\frac{K\rho L^3}{N}, \frac{\rho N^2 L^5}{H.P.}\right) = 0 \qquad \text{[Eq. 5]}$$

or

$$\frac{K\rho L^3}{N} = f\left(\frac{\rho N^2 L^5}{H.P.}\right) \qquad \text{[Eq. 6]}$$

The dimensionless groups described by Eq. 6 were used in this investigation to correlate flotation scale-up and flotation behavior.

Operating Data: The spodumene rougher circuit products from continuous plant and pilot plant operations and batch laboratory tests were sampled to determine the flotation rate for each scale of operation. During the sampling periods, surface treatment and chemical conditions (reagent consumption and pH) were held constant, as they were the same for each scale of operation. The same was true for particle size of flotation feed. For all practical purposes the only variables in each operation were cell design and capacity.

Relationship Between Laboratory, Pilot Plant, and Plant Flotation Performance as Described by Second Order Rate Equation: The *integrated* form of the second order rate equation was used to correlate the flotation rates between the continuous operation of plant and pilot plant cells and batch operation of laboratory cell. This equation was selected because it best fitted the data from the three sizes of cells. Fig. 1 plots flotation time/recovery vs flotation time for each type of cell; corresponding flotation rate constants are tabulated below:

Flotation Cell Size	Flotation Rate Constant, K
Plant	0.09
Pilot plant	0.83
Laboratory	0.50

On the basis of these rates, ratios were calculated for the various flotation cells. Under the operating conditions during testing, for example, 9.2 times as much flotation time would be required in the plant cells to achieve a recovery equal to that obtained in the pilot plant:

Scale of Operation	Flotation Rate Ratio
Pilot plant:plant	9.2:1
Laboratory:plant	5.6:1
Laboratory:pilot plant	0.6:1

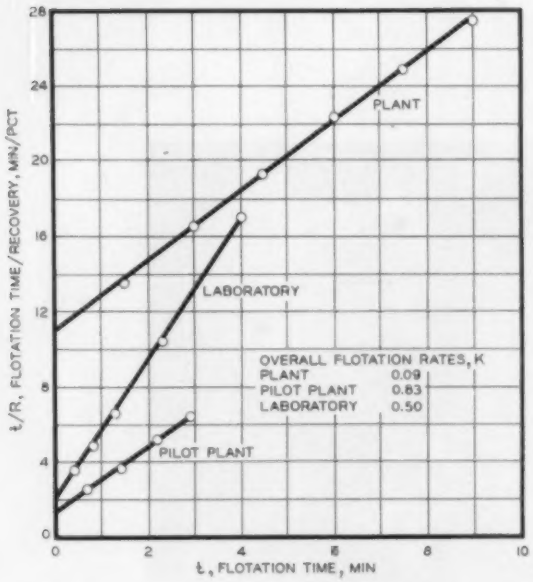

Fig. 1—Flotation time vs flotation time/recovery.

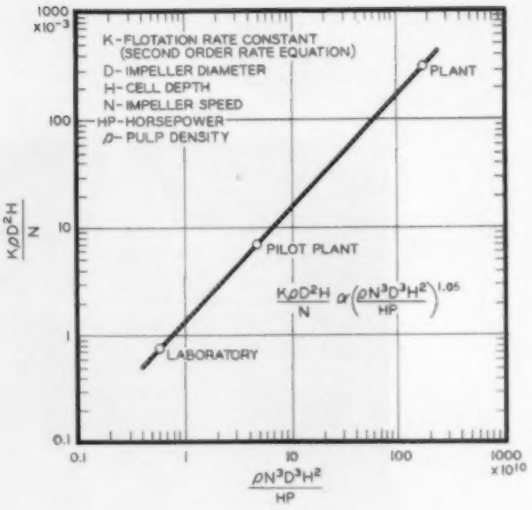

Fig. 2— $\frac{K\rho D^2H}{N}$ *vs* $\frac{\rho N^3D^3H_2}{H.P.}$

Reasons for the varying rates between flotation machine sizes may be numerous and complex. However, on the basis of operating data and flotation rates, a relationship was developed as shown in Fig. 2 which correlates operating variables with flotation rates. Using dimensionless groups the relationship $(K\rho D^2H/N) \propto (\rho N^3D^3H^2/H.P.)^{1.05}$ was found to exist. Although three sets of operating data (scales of operation) are admittedly insufficient to determine an equation involving the two dimensionless groups cited above, the data as shown in Fig. 2 suggest that such a method would make it possible to use laboratory, pilot plant, or plant data to predict results (for one or each scale of operation) for various operating conditions. Undoubtedly other dimensionless groups could be employed to describe existing scale-up relationships for other flotation processes; however, in this application (spodumene flotation) the above relationship satisfied existing conditions based on available data.

Dimensional analysis is an additional tool for predicting plant-scale flotation performance on the basis of laboratory or pilot plant results.

Plant Flotation Circuit Behavior as Described by 1.5 Order Rate Equation: The 1.5 order rate equation was used for this phase of the investigation because it best fitted data for the plant rougher flotation circuit, as shown in Fig. 3, for the various size fractions of spodumene from −30 mesh through 325 mesh. Similarly the 1.5 order rate equation fitted the plant flotation results for the gangue minerals carried over in the rougher concentrate. Flotation rate constants for the various size fractions of spodumene and gangue minerals are recorded in Table II. Data for spodumene are plotted in accordance with the integrated form of the 1.5 order rate equation in Fig. 3.

Data plotted in Fig. 4 illustrate the spodumene content of the plant rougher circuit tailings vs particle size. It may be observed that actual and predicted tailing assays occurring when the rougher circuit retention time was doubled are in excellent agreement in the size range below 80 mesh (see Fig. 3). These size fractions comprise the major portion of the plant flotation tailings. The predicted tailing assays were calculated by using the flotation rate constants (Table II) and assuming a rougher retention time of $2y$. Such an increase in retention time could be achieved by doubling the number of rougher cells or by decreasing the pulp flow one half. The latter method was practiced to attain continuous plant performance data operating with a retention time of $2y$.

Generally in the flotation process it is desirable to collect the concentrate over a minimum period in order to achieve maximum grade. But data in Table III show that there was little difference (74.0 to 77.5 pct spodumene) in the rougher concentrate grade from cells No. 1 through No. 6 (continuous operations).

Flotation rates of the various size fractions of gangue minerals (Table II) were determined to predict the spodumene content of the rougher concentrate resulting from a retention time of $2y$. On the basis of calculated rougher concentrate grade (71.5 pct spodumene) with retention time $2y$, it appears that the counter effect of coarse and fine material would not remain in balance (that is, hold the grade constant) if the retention time were doubled ($2y$). Therefore it would be expected that the rougher concentrate grade would decrease with increased flotation time. However, the finished concentrate was not down-graded when the rougher circuit retention time was doubled (from y to $2y$). On this basis it is evident that a change in flotation time can result in equal or increased concentrate grades with increased recovery even though the rougher circuit retention time is increased. The major source of gangue minerals in the rougher float may be mechanical entrapment and therefore independent of retention time. In any case increased retention time was not detrimental to grade.

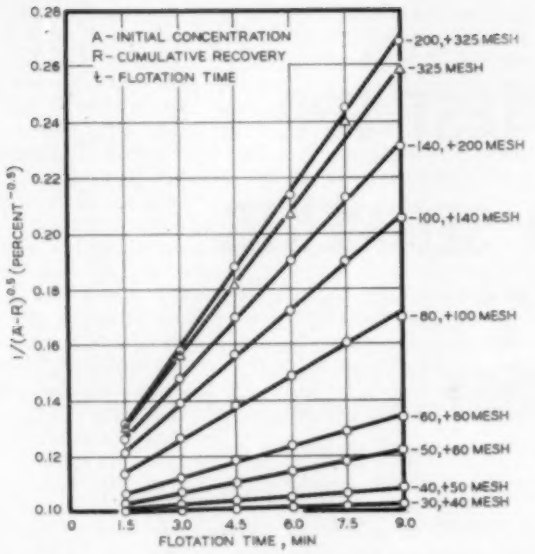

Fig. 3—The continuous plant results, t vs $1/(A-R)^{0.5}$, are plotted here for the various particle sizes.

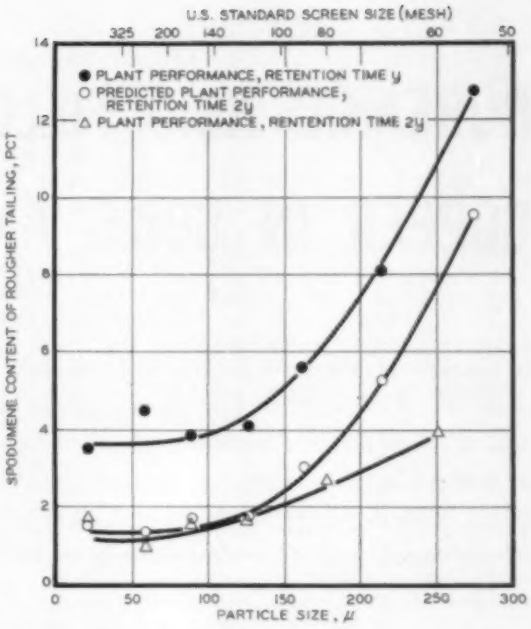
U.S. STANDARD SCREEN SIZE (MESH)
PLANT PERFORMANCE, RETENTION TIME y
PREDICTED PLANT PERFORMANCE, RETENTION TIME 2y
PLANT PERFORMANCE, RENTENTION TIME 2y
SPODUMENE CONTENT OF ROUGHER TAILING, PCT
PARTICLE SIZE, μ

Fig. 4—Above graph presents plant results for the spodumene content of rougher tailing vs particle size.

CONCLUSIONS

Flotation rates and dimensional analysis were used to develop the relationship $(K\rho D^2H/N) \propto (\rho N^3D^5H^2/H.P.)^{1.68}$, which correlates the operating variables with flotation rates as experienced in spodumene flotation. This relationship provides a means for using laboratory, pilot plant, or plant data to make an intelligent prediction of expected results for various operating conditions and flotation cell sizes. Although other dimensionless groups may be utilized to describe existing scale-up relationships for other flotation processes, this procedure presents an additional engineering tool for predicting plant-scale performance based on laboratory or pilot plant test results.

The spodumene content of the rougher tailings produced when the retention time was doubled substantiated predicted results in the size range from 80 mesh down based on calculations using flotation rate constants for the various size fractions. These size fractions comprise the major portion of the flotation tailings.

Although this investigation does not provide reasons for the differences in flotation rates or efficiencies between sizes of cells, it does demonstrate how flotation rate constants (as determined from rate equations) and dimensional analysis can be used as tools for measuring the relative magnitude of these differences.

The writer wishes to thank the Foote Mineral Co. for permission to publish this article, and D. B. Coghlan, assistant director of research, and N. A. Arbiter, consultant, for their interest and constructive criticism.

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Discussion of this article sent (2 copies) to AIME before Dec. 31, 1958, will be published in MINING ENGINEERING.

Table I. Operating Variables

Flotation Machine	Plant	Pilot Plant	Laboratory
Denver cell no.	No. 24 Sub-A	No. 5 Sub-A	500 g
Cell depth	3.38 ft	0.917 ft	0.708 ft
Rated cell volume	50 cu ft	0.248 cu ft	0.106 cu ft
Power intensity	0.059 hp per cu ft	0.125 hp per cu ft	0.563 hp per cu ft
Impeller speed	265 rpm	1200 rpm	1900 rpm
Impeller diameter	1.63 ft	0.375 ft	0.229 ft
Pulp density	81.0 lb per cu ft	77.4 lb per cu ft	80.5 lb per cu ft

Table II. Flotation Rate vs Particle Size, Kings Mountain Plant Rougher Flotation Circuit

Screen Fraction	Average Particle Size, μ	Flotation Rate Constant $(k)^1/(A-R)^{0.5}$ t	
		Spodumene	Gangue Minerals
−30, +40	505	0.07×10^0	0.34×10^4
−40, +50	359	0.18×10^0	1.0×10^4
−50, +60	274	0.50×10^0	1.0×10^4
−60, +80	214	0.75×10^0	1.7×10^4
−80, +100	163	1.56×10^0	2.7×10^4
−100, +140	127	2.22×10^0	3.3×10^4
−140, +200	90	2.82×10^0	5.0×10^4
−200, +325	59	3.73×10^0	8.0×10^4
−325	22	3.20×10^0	11.7×10^4

Table III. Plant Rougher Circuit Concentrate Grade

Cell	Rougher Concentrate, Spodumene, Pct
1	76.1
2	74.2
3	73.6
4	76.6
5	74.0
6	77.5
Combined	75.5

RUBEANIC ACID FIELD TEST FOR COPPER IN SOILS AND SEDIMENTS

In normal soils there are usually 10 to 50 parts of copper in every million parts of soil. Only 0.2 to 5 pct of this copper can be found by any simple cold chemical attack. Now, with rubeanic acid reagent paper, a prospector or field geologist can detect as little as 4 ppm of readily available copper in soil. This degree of sensitivity is enough to determine the presence of copper anamalous areas and, eventually, to discover copper mineralization.

By HARRY V. WARREN and ROBERT E. DELAVAULT

Circumstances determine whether it is better to make analyses in the field or in a permanent laboratory. The rubeanic acid test described in this article has been designed primarily for field use: it is simple and virtually foolproof, and it requires a minimum of field kit.* It is sensitive, easily detecting 4 ppm of readily extractable copper in a soil. This is by no means a quantitative test, but it is accurate enough to provide a valuable indicator of copper anomalous areas for both prospectors and field geologists.

* **Ed. Note:** Persons interested in purchasing kits suitable for rubeanic acid prospecting can obtain information by writing Eldrico Geophysical Sales Ltd., 633 Hornby Street, Vancouver 1, B.C. The University of British Columbia does not produce these kits for sale and has no financial interest in their production.

The easiest method for detecting metal deposits that do not produce visible float or stains is to make a simple chemical test for the metal in overlying soil, or in the silt of a stream that may have picked up metal farther upstream.

In Brief: Testing for copper may be done easily by shaking a soil sample with strong acetic solution in a small test tube and pouring the mud into a small filter, the tip of which rests upon a strip of reagent paper impregnated with rubeanic acid (dithio-oxamide).

When copper is present—and only when it is—a blue spot develops. The more copper, the darker the spot. If the copper content is merely the small amount present everywhere, there is a pale blue or hardly visible spot; if it is abnormally high, the spot will be dark. There are, of course, intermediate cases where the experienced geochemist cannot tell offhand whether a medium-strength spot represents rich agricultural soil, weak copper mineralization, or distant rich copper mineralization. Reagents and material are inexpensive; the test may be readily done on the spot with a simple kit easy to pack and handle.

Anyone interested in general problems of soil sampling as applied to prospecting may refer to an article recently presented to the AIME.[1] In exploration work it is the contrast between the metal content of anomalous and background areas that is important; absolute values become of greater interest when an anomalous area is being investigated in detail. With specific reference to copper, it has been the authors' experience that the amounts of metal extracted from anomalous and normal soils with buffer solutions of decreasing pH show better contrast if an acid reagent is used. This contrast tends to increase with increasing acidity until 3 to 4 pH is reached. Using a short cold attack on unheated soil, it has been found that further increases in acidity do not produce better results, and only increase the hazards involved in carrying strong acids.

An acidity of about pH 4 is satisfactory for direct determination of copper by dithizone. But dithizone itself introduces some problems: it must be made up fresh at frequent intervals, and with some soils, notably those with much ferric iron, oxidation may take place before all the copper has reacted with the dithizone. Rubeanic acid keeps its strength unimpaired for long periods, is unaffected by oxidation, and is practically specific for copper at pH 4. Consequently it seems an ideal reagent to use in prospecting for copper.

History and Background: Rubeanic acid (systematic name: dithio-oxamide $(SC\text{-}NH_2)_2$) has long been known as a spot test reagent for some heavy metals with which it gives a number of compounds. Only copper and some metals of the platinum family are believed capable of providing any rubeanate compounds under conditions of moderate

H. V. WARREN, Member AIME, and R. E. DELAVAULT are, respectively, Professor and Research Associate, Department of Geology and Geography, University of British Columbia, Vancouver, Canada. TP 4783L. Manuscript, May 7, 1958. Northwest Regional Meeting, Spokane, 1958.

acidity (pH 4 to 5) and under the conditions of dilution to be expected in extractants derived from cold soils. Careful tests with as much as 50 micrograms of cobalt or nickel, or 500 micrograms of iron in 1 ml of solution, have produced no reaction on rubeanic reagent paper at a pH near 5. However, it should be noted that rubeanic acid reacts poorly with copper in the presence of large concentrations of ammonium ions.

The use of rubeanic acid for copper prospecting was first introduced in North America by Stevens and Lakin,[2] who advocated a soil extractant of 10 pct acetic acid. They suggested that the spot test be made under controlled and restricted conditions and used a chromograph,[2, 3] which passes a known volume of filtered solution through a strip of reagent paper at a controlled speed. By this technique the spots are reproducible and semi-quantitative determinations are possible.

The above technique is admirable, and, in the authors' opinion, deserves wider recognition. However, the technique is at its best when used in a laboratory. With the modest modifications hereafter described, rubeanic acid can become a potent and reliable tool in the field kit of every prospector.

REAGENTS AND PROCEDURE

Rubeanic Acid Paper: Dissolve 1 g of rubeanic acid (dithio-oxamide) in 100 ml of reagent-grade acetone. Place the resulting solution in a shallow glass or porcelain dish, and pass through it strips of filter paper ½ in. wide and 3 to 4 ft long. (Such strips are sold in rolls for chromatography.) Alternatively the strips can be stretched horizontally and drops of the reagent solution deposited about 1½ in. apart. The reagent is harmless, but it will stain fingers an unsightly black. This, however, may serve as a reminder that the utmost cleanliness is necessary throughout this operation. These strips will dry in a few minutes and, once dried, this rubeanic paper can be wrapped up and stored in any suitable container for months.

Extracting Solution: To make a quantity of solution, take 1 lb (500 g) of hydrated sodium acetate, and 1 qt (1 liter) of acetic acid respectively, and enough copper-free water to make up 1 gal. Both the acetate and acetic acid should be of reagent grade. Should the solution not give a satisfactory blank, when tested with rubeanic paper, the copper can readily be removed by shaking the solution with 50-ml portions of a solution of dithizone, 50 to 100 mg in 1 liter of carbon tetrachloride or chloroform. Rather than spend time removing copper from solutions, it may be easier merely to obtain another source of supply. Actually another batch of chemicals from the same supply house may be found to be copper-free.

Procedure: Place a piece of filter paper about 1 in. square on the bottom of a beaker. Take a strip of the reagent paper 1 to 1¼ in. long, write on one end the identifying assay number, and lay it on the filter paper. Fold a filter paper so that it fits into the beaker. With the pyrex beaker commonly used, 50 ml, the filter must be folded into a cone a little sharper than would be the case if it were being prepared for a funnel. The tip of this filter must be as sharp as possible, and it must just touch the reagent paper. Any twisting or crushing of the filter will cause any spot to be blurred. If polyethylene containers are used, small tabs may be cut in the polyethylene at suitable heights and these may be

EQUIPMENT

Beakers:
Pyrex 50-ml Griffin-shape beakers are good, as are the lower parts of polyethylene bottles that have been cut in two. (See below.)

Test Tubes:
Either glass or polyethylene may be used. The 12-mm size cut 60 mm long is satisfactory.

Test Tube Stoppers:
These may be either of cork or polyethylene and should be soaked in 50 pct acetic acid and carefully rinsed before initial use.

Measuring Spoon:
For the quarter-teaspoon sample required (equal to about 1 g of dry soil) a plastic or aluminum teaspoon or measuring spoon serves.

Glazed Onion Skin Paper:
Cut one 2-in. square piece for each assay.

Filters:
Flat circles, 9 cm, acid-washed, are best. Whitman No. 1 porosity is satisfactory. Some grades or brands, although excellent for ordinary gravimetric work, may be found to contain too much copper, as may be evidenced by unsatisfactory blank tests when the other reagents are known to be metal-free.

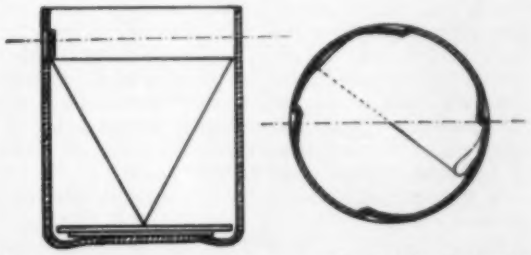

Fig. 1A—Cross sections of apparatus showing how the filter and papers are placed in the polyethylene beaker.

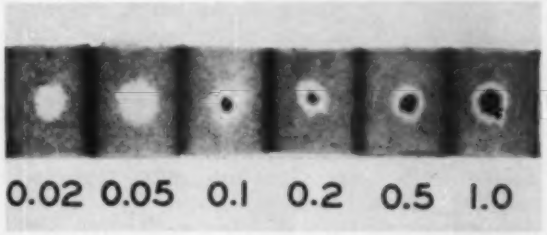

Fig. 1B—These spot tests on the right have been made with absolute amounts indicated in micrograms.

Fig. 1C—Top line, spot tests made recently with 1 g of soil. Approximately 5 pct of the soluble copper contents appears on spot.

Second line, spot tests made with the same soils nearly two years previously, under field conditions.

No. 1, 3, 5, 7, 8, 9, 11 samples taken in immediate vicinity of mineralization. No. 2, 4, 6, 10 samples taken at various short distances from mineralization. All of the above samples were taken from glacial drift that varied in depth from only a few inches up to 40 ft.

pushed in so that the filter paper will be held exactly in place, Fig. 1*a*.

Then on an onion skin paper square place a heaping measuring spoon of the soil to be tested. Using the spoon, sort out any roots or coarse material. Collect a spoonful of as fine and even-grained material as may be practical and transfer to a test tube, using the onion skin paper, the clean side of which may then be wrapped around the stopper. This prevents unnecessary contamination of the stopper if copper-rich samples are encountered.

Add 1 to 2 ml of extracting solution, depending on the dryness of the soil. Just enough extractant should be added to make a thick slurry of the sample, which can then be shaken and poured on to the bottom of the filter. The extractant may be added from a squeeze bottle or a measuring scoop built into the stopper of a pyrex bottle if this is used for carrying the solution. After a short apprenticeship, most operators soon learn to judge closely the amount of extractant that must be added to achieve good and consistent results. After the test tube is stoppered it should be shaken vigorously, some 70 strokes for about 15 sec, and the resultant mixture of soil and extractant poured into the tip of the filter.

Obviously there will be some variations in the amount of the extractant and its contained copper which will pass through the filter on to the rubeanic acid paper. The size and intensity of any resulting spot will indicate the amount of copper present in available form in the sample. As a crude approximation it can be assumed that some 5 pct of the solution will pass on to or through the reagent paper. Nevertheless, this 5 pct seems adequate to indicate even modest copper anomalies in soil once the normal background for an area has been established.

Unless the test tube mixture has been made too liquid and the beaker itself is wetted by a sample rich in copper, the beaker is ready to be used again. Otherwise it must be wiped clean with filter paper. Fortunately any salting from this source is improbable, but should it occur, it can readily be recognized by a general darkening of the reagent paper instead of a normal spot.

Standardization: Under average conditions it can be assumed that 5 pct of the liquid from the extractant passes through the reagent paper. If the sample slurry is not dilute enough less liquid will pass, but it will, of course, be more concentrated. If the sample slurry is too dilute, more solution will pass, but it will be less concentrated than normal. For semi-quantitative work, therefore, it is acceptable to compute the amount of extractable copper in the soil, expressed in parts per million, by multiplying by 20 the absolute amount of copper (in micrograms) appearing on the spot, always assuming that a 1-g sample of soil has been taken. It may be remembered that one microgram per gram represents one part per million.

Spots of known copper content can be obtained by passing extractant solutions containing known amounts of copper through reagent paper under as nearly similar conditions of speed and dilution as might be encountered under field conditions. This last point is very important, because only spots of the same color intensity and size are really equivalent. Fig. 1*b* shows a series of standard spots.

In practice it is possible to identify copper anomalies merely by visual inspections of the spot tests after determining empirically the normal background of the area in which the work is being done.

It may be useful to remember that the drainage status of a particular soil sample can influence the metal content of a soil; low swampy or poorly drained ground is likely to accumulate more copper than corresponding ground that is well drained. Likewise good agricultural land is usually richer than uncultivated land in the same area.

Fig. 1*c* shows spot tests that were obtained 20 months before being photographed, together with their corresponding tests recently made. It can be seen that the tests may be kept a considerable period for reference purposes.

In taking soil samples it is prudent to try to take all samples from one horizon. The horizon just below the layer of organic litter, referred to as the A_1, is recommended. This is the horizon that a non-specialist can most easily be trained to recognize and sample without error. Sampling too high or too low usually obtains too much or too little organic material, errors that can often be observed if the soil is later examined in a laboratory.

The visible intensity of the spots speaks for itself, but aside from the warnings already given, when results are interpreted the limitations involved in any soil sampling technique must be kept in mind. In particular it is well to remember: 1) a soil does not necessarily represent the underlying rock; 2) the amount of heavy metal in a soil may depend more on the ease with which the mineralization weathers than on its grade; and 3) a pattern of high values may represent the spreading of a halo rather than the pattern of any underlying mineralization.

Other Uses: It is possible to test any green or rusty weathering stain for copper. All that is necessary is to soak a strip of reagent paper in the extractant and apply the wet test paper to the material to be tested. If any sizable amount of copper is present, the tell-tale blue-black stain will appear on the back of the paper. Indeed, any rusty gossan or iron-rich residual soil can be tested roughly by sprinkling it on the test paper wetted with the extractant solution and then examining the other side of the test paper.

Stream sediments can be examined in the same manner as soils, although new backgrounds must be established, of course, for each set of new circumstances.

This method was first tried out extensively in the field by Grant Sawyer, of Kennco Explorations (Canada) Ltd., under whose auspices this technique was developed. The authors also extend their gratitude to Northwestern Explorations Ltd., Trisides Mining Co. Ltd., Cardiff Mining Co. Ltd., and H. H. Heustis of Bethlehem Cooper Ltd., for permission to collect samples on Bethlehem ground in the Highland Valley area of British Columbia.

The Defence Research Board of Canada (Grant No. DRB 7510/06), The Geological Survey of Canada, Kennco Explorations (Canada) Ltd., and the Brock Chair provided the bulk of the funds for the laboratory aspect of this project.

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Discussion of this article sent (2 copies) to AIME before Dec. 31, 1958, will be published in MINING ENGINEERING.

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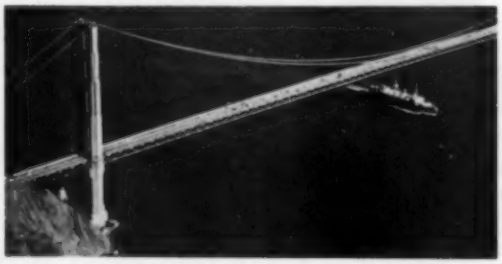
NEXT MONTH–SME's Annual Meeting Abstract and Program Section

SAN FRANCISCO IN FEBRUARY 1959



Golden Gate Bridge–landmark in San Francisco Bay–serves as a reminder of the 1959 February (15 to 19) AIME Annual Meeting. SME's hard-working program committeemen are saluted on page 1191 of this issue.

MINING ENGINEERING's latest innovations in "news" columns are *Education* on page 1196 and *Scholarships* on 1190. On these pages appear late news from the field.

EDUCATION

SCHOLARSHIPS

Mountain skyline and Mormon Tabernacle spires were sights seen in Salt Lake City during the Rocky Mountain Conference.

Page 1198

MINING ENGINEERING *continues to carry a running report, in graphical form, of the progress of the Member Gifts Campaign for the new United Engineering Center — for this chart turn to page 1155.*

NEWSLETTERS . . .

- Coal page 1197
- MBDer's Digest page 1195
- Rock in the Box page 1192

LAST CHANCE

TO ORDER preprints of 1958 SME Annual Meeting papers. See the complete list on page 1144 for any you have missed and still want.

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Scholarships

Soc. of Exploration Geophysicists

The Scholarship Fund of the Soc. of Exploration Geophysicists has awarded 27 scholarships in geophysics for 1958-1959, a total of $21,000. This is an increase of $9000 over last year's educational grants, representing 12 additional scholarships. Two of the scholarships will be financed by the organization's general fund, and the rest are granted by individual companies interested in the geophysical profession.

"The SEG scholarship plan was originated in 1957," announced O. C. Clifford, Jr., president of the Society, "for the purpose of promoting the science of geophysics through improving the training of geophysicists. We feel that the expansion of our educational program through establishing a foundation with broad purposes, will eventually provide for research grants, teaching fellowships and other aids to universities. This will offer a chance for cooperation in supporting basic research in geophysics."

The SEG, with headquarters in Tulsa, Okla., supervises the impartial selection of scholarship winners, based on their previous scholastic record and their desire to obtain the training needed for a career in exploration geophysics.

International Nickel Co.

A $4000 teaching fellowship has been renewed for the University of Oklahoma by the International Nickel Co., providing $1000 to the school for equipment and supplies and the rest in the form of a scholarship grant. International Nickel carries on a multi-million dollar program of support for higher education to encourage students to continue in graduate study. It is hoped that many students helped by the funds will enter the teaching of science, particularly metallurgy.

AIME

BOARD OF DIRECTORS

Recent actions taken by the Institute Board of Directors.

► The newly established Carolina Subsection has been authorized to change its name to Western Carolina Subsection, since there is an Eastern North Carolina Subsection of the Southeast Section.

SME Program Coordinator, Division Chairmen Wrap Up Plans For San Francisco

The Program Chairmen for the Annual Meeting in San Francisco are in the midst of arrangements for the technical sessions. Co-ordinator for the Society program chairmen is R. M. Grogan. The Coal Division program chairman is W. E. Hess and the other division chairmen are R. H. Feierabend for IndMD; R. J. Lacy for M&E; and W. L. Dowdey for MBD.

Although the meeting will not take place until February, deadlines for papers have long since passed and final details are being arranged by the chairmen responsible for scheduling the papers. The numerous jobs of these hard-working chairmen include keeping in touch with the authors, forwarding papers to SME headquarters for preprinting, plus all the publicity necessary to keep members alert to meeting plans.

Hard-working SME Director **Robert M. Grogan** has had the task of coordinating the efforts of the four Division program chairmen into a polished final schedule for the San Francisco Annual Meeting. Associated with the Development Dept. of E. I. du Pont de Nemours & Co., Wilmington, Del., Mr. Grogan represents IndMD on the SME Board. A native of Mendota, Ill., he received a B.S. from the University of Chicago, attended the University of Illinois, and earned M.A. and Ph.D. degrees at the University of Minnesota. During and after the acquisition of his advanced degrees, Mr. Grogan was associated with the Industrial Minerals Div., Illinois State Geological Survey at Urbana. He joined Du Pont as a geologist in 1951.

His work for Du Pont has required extensive travel in search of raw material sources of fluorspar and titanium. He also had experience with fluorspar consulting work in Indiana and Kentucky, and was a consultant to the Armour Research Foundation in Mexico.

Ray Feierabend has kept members in touch with the program plans through the IndMD newsletter in July, revealing committee plans for papers and joint sessions. Mr. Feierabend is a native of Little Rock, Ark., where he attended school until he went to Columbia for an A.B., and a B.S. from the Columbia School of Mines in mining engineering. He also attended Harvard Business School.

He began his long association with Freeport Sulphur Co. in 1942 as junior engineer in Hoskins, Texas. Soon Mr. Feierabend advanced to field engineer, production engineer, production superintendent, and finally general superintendent of the Grand Ecaille Mine in 1953. He has been stationed in New Orleans and was elected assistant vice president. Mr. Feierabend has served AIME on the National Membership Committee, the Mining Subdivision Program Committee, and was also on the Field Trips and General Committee for the Annual Meeting in New Orleans.

R. J. Lacy is the program chairman for the Mining & Exploration Div. and has been busy reminding contributors of the paper deadlines. He is chief geophysicist for American Smelting & Refining Co., Salt Lake City. After graduating from the University of Minnesota in 1937 with a degree in mining engineering, he became a mine geologist for The Anaconda Co. in Butte, Mont. In 1946 he joined the California Co. as a geological observer on exploration parties. He did some post-graduate work at his alma mater, then accepted the post of geologist with Asarco in 1948. He has been elected assistant chairman of M&E, taking office in February 1959.

W. L. Dowdey, elected division chairman of MBD for 1959, is also program chairman for the Annual Meeting for his division. He is the regional manager for The Eimco Corp. in the Birmingham and Pittsburgh areas. He was born in Alabama and brought up in the coal mining areas there, attending Martha Berry College in Rome, Ga., Howard College in Birmingham, and Alabama Polytechnic Inst. He began his mining career with Republic Steel Corp. at blast furnaces in Birmingham, and worked through various positions to mill superintendent at the Spaulding, Ala., operations.

In 1945 he became associated with Eimco as a sales engineer, and was appointed manager of the Southern District in 1950. He joined AIME in 1945 and has served on various MBD technical committees, has been MBD secretary-treasurer, and regional vice chairman before being elected chairman.

The Coal Div. program chairman is also a vice president of the Coal Mining Inst. of America. **W. E. Hess** is manager of coal mines for Vesta-Shannopin Coal Div. of Jones & Laughlin Steel Corp. He received his B.S. from Pennsylvania State University and was a mining engineer for Consolidation Coal Co.

At one time he was general superintendent for Elk Horn Coal Corp., and later he was safety director for the Mallory Coal Co. His other supervisory positions include his former job as general superintendent of Princess Elkhorn Coal Co. and as assistant general superintendent for Island Creek Coal Co.

In addition to AIME, he has served the American Mining Congress as chairman of the Mechanical Loading Committee, and is a member of the Pittsburgh Coal Mining Inst.

Russian Mining Trends, Instrumentation, To Be Duluth, Minn., Subjects

The Minnesota Section will hold its annual meeting in Duluth on Jan. 12, 1959, followed by the Annual Mining Symposium sponsored by the University of Minnesota.

The AIME meeting will feature three well known mining men who have recently returned from visiting Russia. E. L. Joppa, general manager, Pickands Mather & Co., will report on his impression of Russian mining methods and equipment. D. N. Vedensky, director of research and development for The M. A. Hanna Co., will describe the Russian beneficiation methods and plants. J. H. Strassburger, assistant vice president of Weirton Steel Co., will present a first hand report on Russian steel operations.

The remainder of the formal AIME session will include a report by J. S. Breitenstein on the use of the R-N process for the direct reduction of Mesabi Range iron ores.

Symposium Plans

Dean Nolte of the Center for Continuation Study of the University of Minnesota reports instrumentation will be the topic of the meeting on January 13 and 14. The 20th Annual Mining Symposium will be introduced with a discussion of instrumentation in general and its application to the mining industry followed by two sessions: one devoted to instrumentation in beneficiation and one to mining instrumentation.

ROCK IN THE BOX

Mining & Exploration Division

R. S. Archibald Named 1959 Jackling Lecturer

The Daniel C. Jackling Award and Lecture was established in 1953 to honor the late Daniel Cowan Jackling, Honorary Member and Past-President of AIME. The award consists of a bronze plaque bearing the likeness of Dr. Jackling and engraved with the name of the recipient and his citation of achievement. It is presented for significant contributions to technical progress in the fields of mining, geology, or geophysics and for the lecture which the recipient presents at the Annual Meeting.

This year the man who has been chosen as deserving of the award is Ralph S. Archibald, chairman of the board of directors of North Range Mining Co., Negaunee, Mich. Mr. Archibald retired in May as president and general manager, but continues close watch over company affairs.

He was born in 1884 in Trinidad, Colo., and his family moved to Washington, D. C., when he was 12, where he attended school until he entered Lehigh University, graduating with an E.M. degree in 1907.

His first job after graduation was as a geologist with the Cleveland-Cliffs Iron Co. at Ishpeming, Mich. Mr. Archibald worked at CCI for three years until he joined M.A. Hanna Co. in Duluth and became chief engineer the following year. He became mine superintendent for M.A. Hanna Co. in 1912.

After three more years he felt that he had sufficient grasp of his profession to strike out for himself. His consulting practice was carried on continuously throughout the years that followed. Mr. Archibald became consulting geologist for the Jones and Laughlin Steel Corp. and was manager of the C. K. Quinn interests in Michigan.

Mr. Archibald explored the iron ore lands of Upper Michigan for Palms-Book Land Co. in the 1920's, and in 1930 he also examined land in Minnesota and Wisconsin for the Inland Steel Co. His work for Inland involved advice in connection with the acquisition of limestone lands in upper Michigan which are now the site of Inland Steel's limestone quarries. His long period of active service with Inland Steel was terminated by retirement in 1954.

He also acted as consulting geologist for the Santa Fe Railroad in connection with the first discoveries and later development of the uranium deposits in the now famous Grants, N. M., area. His consulting work has taken him all over this country and into Mexico and Cuba.

In 1933 with several associates he organized the North Range Mining Co. and built up its operation from a small beginning as operator of the Blueberry Mine on the Marquette Range in Michigan, to a very substantial operation of several mines. These underground iron ore mines were Mr. Archibald's chief concern though he also operated open pit mines in Michigan and gold and lead-zinc mines in Montana and Idaho. More recently North Range has entered the uranium mining field in Utah.

Mr. Archibald's contributions to the development of the technology of the industry have been many and his community and social activities cover a wide area. He has been chairman of the AIME Upper Peninsula Section and secretary of the Lake Superior Mining Inst. He is now a director of the American Iron Ore Assn. and a member of the American Iron and Steel Inst.

In 1953 Mr. Archibald received the Lehigh University Alumni Assn.'s Special Award "in recognition of well merited prominence as a geologist, mining engineer, mine operator and financier . . ." His role in civic welfare, state, and federal Government, on the industry advisory committee, has earned him the respect of fellow citizens. He has been president of the First National Bank of Negaunee, director of the Michigan Children's Aid Soc., and active in many other social and community affairs. He easily deserves this most recent honor as lecturer and recipient of the Daniel C. Jackling Award.

The committee responsible for this year's decision was headed by H. Carroll Weed of Inspiration Consolidated Copper Co. His committee members are: Lyman H. Hart, H. E. Hawkes, Jr., R. C. Holmer, H. M. Mooney, R. D. Satterley, C. L. Wilson, and E. H. Wisser.

The annual invitational address by an outstanding man who has contributed to the progress of technology recalls the life of the man for whom the award is named. The life of Daniel Cowan Jackling followed the tradition of the American success story. He was a true pioneer in the broadest sense of the word.

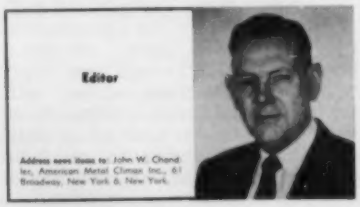
Selection of New Unit Committee Chairmen

The Bylaws of M&E call for each Unit Chairman to canvass the membership to determine their choice for his successor. The most democratic way to do this is through *Rock in the Box*. Unit Chairmen (names and units are listed below) will welcome your suggestions—which should be in their hands within the next 30 days.

Please contact the following Chairmen:

Underground Mining	J. M. Ehrhorn U. S. Smelting, Refining & Mining Co., Newhouse Bldg., Salt Lake City, Utah
Open Pit Mining	W. A. Pakkala The Cleveland-Cliffs Iron Co., Hibbing, Minn.
Geology	W. W. Simmons Miami Copper Co., Box 100, Miami, Ariz.
Geophysics	Robert J. Searls Newmont Mining Co., 300 Park Avenue, New York 22, N. Y.
Geochemistry	Herbert E. Hawkes, Jr. Div. of Mineral Technology, University of California, Berkeley, Calif.

The way to make SME and M&E work is for everyone to take a definite interest in our Division. *LET'S HEAR FROM YOU.*



Symposium at Missouri On Explosives Research

The Fourth Annual Symposium on Mining Research is being held on November 13 through 15 at Rolla, Mo. It is sponsored by the University of Missouri School of Mines and Metallurgy and the U. S. Dept. of the Interior, Bureau of Mines.

Registration begins Thursday morning at the Mining Bldg. The welcoming address will be given by Albert W. Schlechten, chairman, Dept. of Metallurgical Engineering at Missouri. John L. Romig will present the first paper entitled *Giants at Little Valley-Promontory Point Blasts*. Other papers on the morning session will be *The Ripple Rock Blast* by C. H. Noren and *Phenomenology of Contained Nuclear Explosions* by Gerald W. Johnson.

After the luncheon intermission a second session will include three papers: *Mathematics of High Explosive Calculations* by George B. Clark, *Calculation of Explosive Parameters by Digital Computers* by Donald J. Kaufman, and *A Method of Calculating Homogeneous and Heterogeneous Equilibria and Explosion Temperatures of Condensed Explosives* by Jack Alster.

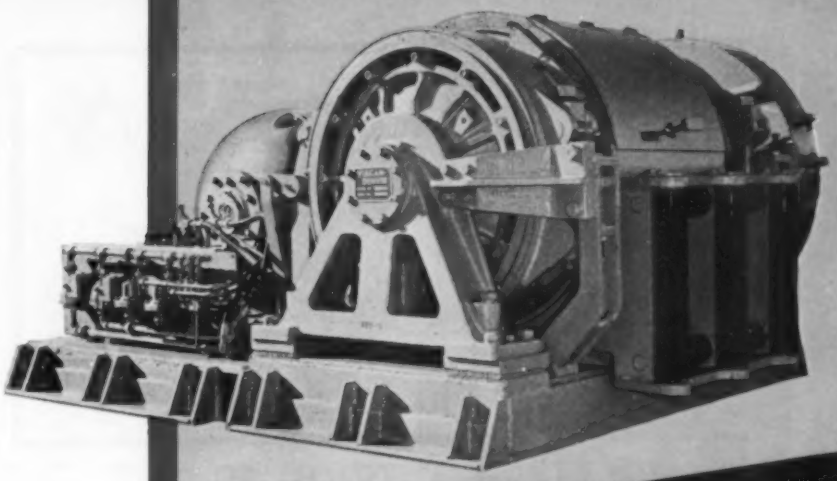
The meeting will adjourn for the afternoon and return at 7:00 p.m. for dinner at the Edwin Long Hotel, where Royce A. Hardy, U. S. Assistant Secretary of the Interior, Mineral Resources, will be the speaker.

On Friday the session will begin early with a paper by Wilbur I. Duvall on the *Propagation of Explosive-Generated Strain Pulses in Rock*. Then there will be a special *Water-Compatible Explosives Session* with three papers: *Water-Compatible Ammonium Nitrate Explosives for Commercial Blasting* by M. A. Cook, *Development of Physical Properties and Techniques Suitable for Commercial Applications of Slurry Explosives* by J. F. C. Dixon, and *Blasting Results From Full Scale Use of Slurry Explosives* by H. E. Farnum, Jr.

After lunch four more papers will be given. Rufus C. Ling will discuss *Blast Performance of High Explosives*. R. L. Grant and R. W. Van Dolah will present their paper on *Application of Statistics to Explosives Testing. Some Studies in Ammonium Nitrate-Fuel Oil Compositions*, next in the schedule, is prepared by W. E. Tournay, G. H. Damon, and R. W. Van Dolah. And finally Dean G. Wilson will give his paper on *Comparative Testing of Ammonium Nitrate-Fuel Oil Explosives*.

At the final session on Saturday morning new research will be emphasized in three papers: *Research on the Effects of Physical and Chemical Properties of Ammonium Nitrate Explosives* will be presented first. The paper was prepared by R. F.

(Continued on page 1200)



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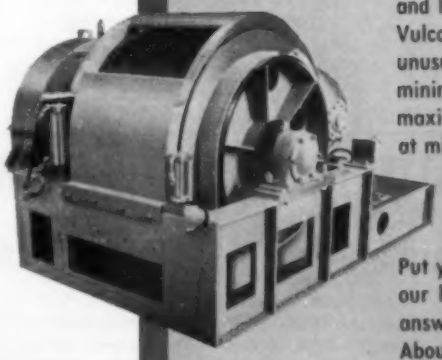

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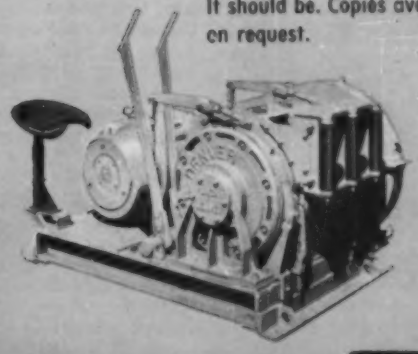

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AIME NEWS

ENGINEER*

"EJC's Report on What's Happening in Engineering"

*A Periodic Newsletter from Engineers Joint Council • 29 W. 39th Street, New York 18, N.Y.

It's Now EJC, Inc.

By action of the board of directors on July 10, following acceptance by the members, EJC became "Engineers Joint Council, Incorporated," a membership corporation of the State of New York. The officers of the corporation, transferred by formal vote, include Enoch R. Needles as president; O. B. J. Fraser, vice president; E. L. Chandler, treasurer; E. P. Lange, secretary; and L. K. Wheelock, assistant secretary.

1959 Nuclear Congress

Cleveland will be the site of the 1959 Nuclear Congress next Apr. 5 to 10, 1959. To expedite programming, chairman Clarke Williams of the Nuclear Science and Engineering Conference is urging authors to submit 300 to 500-word summaries of proposed papers to the secretary of any one of the 28 sponsoring societies by Oct. 1, 1958. The list of the sponsoring societies is available at EJC headquarters, 29 W. 39th St., New York. For general information on Nuclear Congress, contact T. A. Marshall, Jr., Congress manager, or L. K. Wheelock, assistant manager, c/o Engineers Joint Council in New York.

Placement Survey of 1958 Engineering Graduates

Despite unfavorable economic conditions in the country, only 10 pct of graduate engineers had no definite plans by late May, and by June all had been offered positions. A month before graduation 83.5 pct of an estimated 33,000 graduates of the class of 1958 were employed. Placement opportunities for new engineers are remarkably stable. For a full report, address EJC in New York.

National Transportation Policy

The development of a national transportation policy is being considered by the EJC board, based on the proposal by ASME. A detailed report of the background of this proposal has been forwarded to the societies, asking for nominations to an exploratory group to consider the question.

Engineering vs Technology

Of major concern to EJC's Public Relations Committee are continued references in the press, radio, TV, advertising, and statements out of Washington to the phrase "science and technology" rather than the more accurate "science and engineering." EJC urges its members to help correct this fuzzy phrase with its proper designation.

New Member

The American Inst. of Plant Engineers became an associate member of EJC on July 10. There are now 19 societies within the membership. They are:

Constituent Societies—ASCE, AIME, ASME, AIEE, AIChE, American Water Works Assn., American Soc. for Engineering Education, American Soc. of Heating and Air-Conditioning Engineers, American Soc. of Refrigerating Engineers, The Soc. of American Military Engineers, and The American Inst. of Industrial Engineers.

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Remember, in the membership slogan the hands symbolize—*Every Mining Man Should Be a Member of the Society of Mining Engineers of AIME.*

I am interested in the Society of Mining Engineers of AIME and would like to receive further particulars.

My primary interest is in:

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- ☐ **Coal**
- ☐ **Minerals Beneficiation**
- ☐ **Industrial Minerals**
- ☐ **Other**

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COMING EVENTS to note . . .

DATES	MEETINGS	CITY
Oct. 31-Nov. 1	AIME Central Appalachian Section and West Virginia Coal Mining Inst.	White Sulphur Springs, W. Va.
Nov. 7	AIME Pittsburgh Section and AIME NOHC Pittsburgh Section 13th Annual Off-the-Record Meeting	Pittsburgh
Dec. 1	AIME Arizona Section Annual Meeting	Tucson, Ariz.
Dec. 5	AIME Lehigh Valley Section	Allentown, Pa.
Dec. 6	AIME Eastern North Carolina Subsection, Southeast Section	Henderson, N.C.
Dec. 11	AIME Utah Section	Salt Lake City
Feb.15-19, 1959	AIME Annual Meeting	San Francisco

For a more extensive list, turn to page 1125.

mB*d'ers* digest

Embie Dee says: *Read about our ship-shape MBD program for the big AIME San Francisco Annual Meeting.*

The MBD Division has prepared a program outline for their part of the Annual Meeting in San Francisco next February. They plan to have eight sessions, including symposiums and two joint sessions with the Extractive Metallurgy Division of The Metallurgical Society.

The first session will cover the topics of crushing and grinding with four or five papers. Three have been decided upon to date and are entitled: *The Gyratory Ball Mill, Its Design, Principle of Operation, and Performance*, by A. W. Fahrenwald; *Crushing Practice at Silver Bay Taconite Plant*, by A. S. Henderson, E. M. Furnace, and F. E. MacIntire; and *Pebble Milling Practice in the Reduction Works of the Gold Mines of Union Corp. Ltd.*, by O. A. E. Jackson. Session co-chairmen are E. C. Herkenhoff and R. K. Poull.

The second session will be a symposium on solids-fluid separation entitled *Theory, Design, and Operation of Counter-Current Decantation.* D. A. Dahlstrom and J. D. Vincent will chair the meeting. The first paper will be on *Counter-Current Decantation—When and Why*, by Elliot J. Roberts. R. R. Porter is scheduled to give the second talk, but his subject has not yet been announced. D. J. I. Evans and A. J. Lindsay have collaborated on the third paper titled *Thickening Leach Residues In the Sherritt Gordon Nickel Refinery*, and Morton Handelman will give the final paper on *Separation and Washing Alumina Process Residue.*

James H. Robins will be the chairman for a session on materials handling. Four papers to be presented are *The Wobbler Feeder*, by T. A. Oberhellmann; *Flow of Bulk Solids Project*, by Andrew W. Jenike; *Belt Conveyor Power Studies*, by A. W. Asman; and *Stockpiling Purposes, Methods, and Tools*, by Lawrence O. Millard.

Session IV will cover concentration, and the chairmen will be R. H. Lowe and R. J. Mellen. Three of the four papers have been chosen. W. R. Van Slyke will discuss *Scrubbing of Mesabi Range Intermediate Iron Ores.* C. J. Veale will give his paper on *Consideration of Practical Ore Dressing Problems That Are Seemingly at Variance with the Theoretical.* The final paper selected to date will be *Two Years Milling at Bicroft Uranium Mines Ltd.*, by D. F. Lillie, W. J. Dengler, and I. C. Edwards.

Two joint sessions on chemical process will be held with EMD. The first session will cover nickel and be chaired by John Dasher of MBD and W. Martin Fassell of EMD. V. N. Mackiw will give the first paper entitled *Refining of Nickel-Copper-Cobalt Mattes by Pressure Leaching and Hydrogen Reduction.* D. W. Bridges will discuss *Cobalt Nickel Separation—An Investigation of the DeMerre Process. Modifications in Nicaro Metallurgy* has been prepared by Armando Alonso and John Daubenspeck. *Pressure Leaching and Electrowinning of Cobalt at the Garfield Refinery of the Calera Mining Co.* is the title of J. S. Mitchell's paper, and Jim Shea's topic will be *Ammonium Sulfate Leaching-Hydrogen Reduction Process for Treating Nicaro Bulk Precipitate.*

The sixth session will be a symposium on Fatty Acid Flotation with F. T. Davis and G. L. Sollenberger as chairmen. The four papers have been selected and are as follows: *The History of Fatty Acid Flotation*, by George H. Roseveare; *Single Mineral Flotation with Linolenic, Linoleic, Oleic, and Stearic Acids*, by Sciou-Chuan Sun; *Fatty Acid Flotation with Fatty Acids of Different Composition*, by Stuart A. Falconer; and *Feed Preparation and Mineral Coating in Fatty Acid Flotation*, by Carl C. Martin and Burt C. Mariacher.

The session on mill design is not yet complete. Harry L. McNeill and Charles N. Bailey are the co-chairmen, and two speakers have been chosen, but only one paper title has been announced. E. Vern Given will discuss *Design Requirements for Tailing Disposal in the Southwest.* John Blackshaw is also scheduled to speak, and two others are yet to be chosen.

The final session is the second part of the joint session with EMD on chemical process. Session B is on uranium, and R. D. MacDonald and Bruce Clemmer are the chairmen. *Blind River Hydrometallurgy* will be the first paper, given by R. P. Ehrlich. T. L. Mackay and M. E. Wadsworth will present a paper entitled *Kinetic Study of the Dissolution of UO_2 in H_2SO_4.* Clyde W. Garman will talk on *Working the Kinks Out of the Homestake-New Mexico Partners Mill*, and K. Lentz will give the final paper of the session, discussing *Union Carbide's Uranium Operation at Maybelle, Colo.*

Further program developments will be reported as details become available.

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Education News

George S. Rice Library

The George S. Rice Memorial Library, named for one of the Nation's foremost pioneers in mine safety, was dedicated on June 19, at the Bureau of Mines' Anthracite Experiment Station, Schuylkill Haven, Pa.

Dr. Rice, the Bureau's first chief mining engineer, died in 1950 after a long career devoted to studies of mining technology and safety problems. Valuable technical books and reference material he had acquired were formally presented to the Bureau by his widow, to be kept in the library for reference to industry, students, and others interested in coal technology. The Bureau also received a portrait of Dr. Rice, painted by his daughter, Katherine Ballinger.

A light luncheon and a tour of the Schuylkill Haven station was held in conjunction with the dedication.

Colorado School of Mines

In its 85th year of academic training devoted exclusively to engineers of the mineral industries, the Colorado School of Mines has appointed 12 new faculty members. The school has maintained a student-faculty ratio of ten-to-one with a full time teaching staff of 110. Three of the newly appointed faculty members will move into a new $1 million classroom and laboratory building. This metallurgical engineering building will be the academic home for 250 metallurgical students, triple the enrollment of five years ago.

When Colorado School of Mines opened in September, the $1 million metallurgical engineering building, above, was placed in operation without formal dedication ceremonies. Nearly 250 metallurgy students now are working in the new building.

• In a move to strengthen and maintain the high academic standards of the Colorado School of Mines, the board of trustees have revised the admissions policy to take effect in 1960. The Scholastic Aptitude Test of the College Entrance Examination Board, required of out-of-state students since 1954, will be required of all students after 1959.

The school will continue to use the general requirement that applicants be in the upper third of their high school graduating class, and borderline cases will be given the school's own pre-engineering inventory examination.

The Colorado School of Mines has traditionally held its number of scholastic drop-outs to an unusually low level despite the heavy academic schedule. It is expected that the Educational Testing Service examination will facilitate the careful selection of qualified students who can maintain this excellent record.

North Carolina State College

The North Carolina Engineering Foundation plans to finance the establishment of seven distinguished professorships in the School of Engineering at North Carolina State College. Since it was organized in 1944, the Engineering Foundation has helped support the school itself, and this additional assistance is designed to retain and attract top-ranking teachers and scientists for service on the staff. Now the college will be able to supplement the State salary scale and offer substantial increases to outstanding engineering educators.

Russian Education

The question of adequate scientific training in American high schools has been a hot issue since the sputnik scare, and the topic for many Local Section meetings.

In a *New York Times* editorial it was pointed out that many "invidious comparisons" of Soviet and American school systems have indicated that hard work is demanded of Russian students while our boys and girls can relax in a bath of liberal arts. The *Times* notes the "irony in Premier Khrushchev's exposé of the Soviet Union's educational troubles and his radical proposals for their elimination." Now the majority of Soviet youngsters will have to quit school at age 15 and go to work. The "exceptionally gifted" may go to night school or take correspondence courses to qualify for further education.

To quote the *Times'* main point: "These revelations should be salutary in refuting any belief that a solution of our educational problems lies in simply imitating the Soviet system. The case for better education in science and mathematics here—and it is a strong case—must be justified in terms of our own present and prospective needs, not in any hasty conclusions born of individual Soviet scientific successes, such as the sputniks."

There are deeper questions to consider in answering our own shortcomings. Khrushchev's solution is "profoundly anti-democratic." We must find methods of improvement that are consistent with our principles of education for all.

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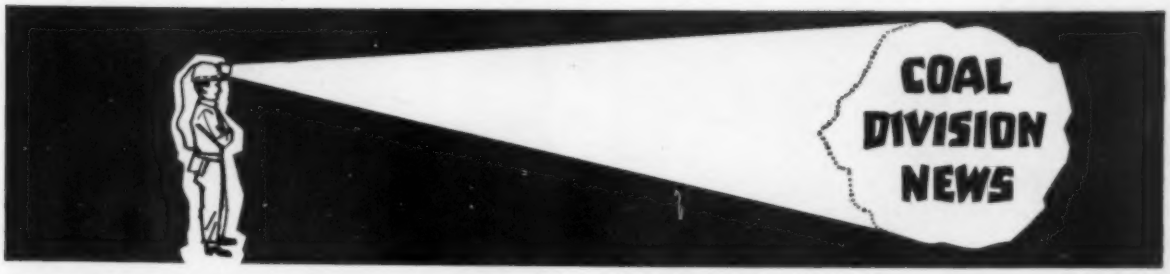

The Coal Division's active student representatives cooperated with WAAIME, Western Pennsylvania Section, this summer when WAAIME launched a project aimed at secondary school students.

The success of this *Pilot Student Venture* has prompted enthusiastic response from all concerned, the industry leaders, the college staff, WAAIME, Coal Division members and the boys themselves. The aim of the project is to help students today become engineers tomorrow.

To stir the interest and imagination of prospective engineers, the WAAIME leaders in the Pittsburgh area chose ten science-minded high school boys for their first experiment—exposure to actual mining life. This trial operation took place in July at the West Virginia University School of Mines where the boys stayed for five days under the direction of G. Ralph Spindler.

From this base the boys visited underground operations and preparation plants, saw explanatory movies, and talked with college members, engineers, and other industry personnel who could answer their questions about the mining field.

Now that the first attempt has been made, WAAIME is considering the project from all sides and has many suggestions for the future. The basis for their hope in a nationwide program of education and encouragement for students considering mining is the reaction of the students themselves.

The boys were asked to write their approval or suggestions after their exposure to mining life, and all response was favorable. They commented on the helpfulness of the miners themselves, the interesting talks and answers to curious questions as they toured the mines. They discovered how up-to-date the mining facilities are, erasing some of their mistaken ideas of hand methods long discarded. One boy said that he "was also surprised to find that mining involved every branch of engineering."

"It was a wonderful experience, one I'll never forget. The trip underground was very interesting and exciting. Friday evening after a fine dinner at the country club we talked with men from the mining industry and the university. We asked questions and found out specific things we were interested in about the jobs, etc. These personal contacts were highlights of the trip."

All the boys commented about the thrill of their first visit to an underground mine in action. The leaders of the project learned that more experiences of this nature should be featured in future trips. One boy declared that "visiting the various installations described what was going on better than the best books or teachers could ever attempt to do. In my opinion these trips should be continued. It is a good way to help someone like me to make up his mind about choosing a vocation."

These were the votes of thanks from the students themselves. They showed that the project accomplished its several goals. It gave the boys a real taste of mining life. It introduced them to interesting and encouraging engineers who could give them some personal guidance. It presented the college program and explained the requirements of the field. And most of all, it started them thinking of their future in terms of mining, and showed them that engineering can be fun.

"I enjoyed every minute of it, it was very informative and I am now convinced that it is the field in which I will make my career. One of the things that impressed me most about the coal mining industry was the people associated with it. I have never met a nicer group of men. It also showed me the opportunity in the mining field for advancement."

Not only the boys themselves, but

(Continued on page 1200)

Correction

In the September issue, p. 1014, a typographic error resulted in the misspelling of the name of the third member of the Coal Division Executive Committee. R. G. Lazzell, Island Creek Coal Co., Huntington, W. Va., this third member, will begin a three-year term in February 1959.

Outfitted in coveralls and mining helmets, the boys take part in the "Pilot Student Venture" initiated by WAAIME in July, with cooperation on this initial trip from Coal Division members. Boarding the bus, left, are: Warren Fisher, Woody Thiesen, Jim Flinn, Bob Muskat, Walter Craig, Paul Franklin, Duff Sensenich, Reg Knapp, Paul Franklin, and Chuck Tillson. At the right, company personnel from Mountaineer Co. join the boys for a group shot before an afternoon tour of the Jamison No. 9 mine.

Enjoying the cocktail party are J. L. Gillson, Mrs. Michaelson, Mrs. Gillson, and S. D. Michaelson. Previewing a fall fashion are, left to right, Mrs. Paul L. Shields, Mrs. W. G. Rouillard, Mrs. George D. Clyde, and Mrs. J. R. C. Mann.

UTAH SECTION HOSTS MEETING

Three Boards—AIME, SME, TMS—Meet in Salt Lake City

As the 1958 AIME Rocky Mountain Minerals Conference convened in Salt Lake City on September 17, the Utah Section, meeting host, took pride in drawing not only the AIME Directors but the Boards of the Society of Mining Engineers and The Metallurgical Society to their area for fall sessions. They also pointed with an equal feeling of honor to the notable technical papers on the program for members of the Society of Petroleum Engineers.

The gratitude of the AIME Board was expressed in a formal resolution of thanks and appreciation, voted at the September 19 meeting and placed in the official AIME Board minutes.

A final honor for the Section came in the midst of the AIME Board meeting, September 19, when Dr. Joseph Gillson, Chairman of the Member Gifts Campaign for AIME in the drive for funds for the new United Engineering Center, announced that the Utah Local Section had gone over its quota at 1:00 pm that afternoon, the first AIME Section to do so.

The Conference program included notable technical sessions (abstracts of some of the papers presented are given on p. 1132B). The *Modern Management Techniques* symposium played to *standing room only* as a panel of experts in the various phases of management gave a comprehensive picture of new methods and practices.

The program was also replete with gala social events such as luncheons, cocktail parties, dinner, and miner's breakfast at which, to quote the program, guests appeared unshaven in western garb. Final registration figures exceeded the 600 mark, including ladies.

Above are, top, AIME President and Mrs. Augustus B. Kinzel, and next Mr. and Mrs. R. B. Ladoo. Below, J. D. Forrester, Arizona University's School of Mines (to be the site of a symposium in March), confers with General Conference Chairman A. J. Thuli. In the background is E. C. Stephens, who was a committee member for the 1958 AIME Pacific Northwest Conference.

Salt Lake City notables at the meeting are, left to right, P. H. Ensign, N. L. Weiss, Mrs. Ralph Tuck, and R. C. Cole. All are officers of the AIME Utah Local Section.

Four Presidents attending the meeting intently study a U. S. map, part of Institute "territory." Clockwise, left, are Augustus B. Kinzel, AIME President; S. D. Michaelson, SME President; W. R. Hibbard, Jr., TMS President; and Howard C. Pyle, AIME President-Elect. Professionally they represent all three interests—mining, metals, and petroleum. J. L. Gillson, below, reported to the meeting on progress of the Member Gifts Campaign for the new United Engineering Center to be erected in New York. Now AIME Vice President, Dr. Gillson takes office in February 1959 at the San Francisco Annual Meeting as President-Elect.

One of the relaxing moments during a conference comes when old (and new) friends pause to chat at social events. Above are P. H. Ensign, R. C. Cole and Ewald Kipp, elected SME Director for 1959. Messrs. Ensign and Cole are, respectively, secretary-treasurer and chairman of the Utah Section. On the opposite page are two other officers, Mrs. Tuck, chairman of the Section's Woman's Auxiliary, and Mr. Weiss, vice chairman and also SME Director-Elect. Professionally the men above are connected with Kennecott Copper Corp., Vitro Uranium Co., and Eimco Corp. Kennecott and Eimco were field trip stops during the meeting. Below are Elmer Jones, Howard C. Pyle, and John Kinnear. The latter three are "Presidents," SME Past. AIME Elect, and TMS Past.

Men from all over the country enjoy an opportunity to be together. Below are Roger V. Pierce, Salt Lake City; R. B. Stephenson, Philadelphia; R. W. Lawson, Salt Lake City; and R. R. McNaughton, Trail, B. C., Canada. These gentlemen are also active AIME'ers—AIME Director, SME Director-Elect; Assistant General Conference Chairman, and past officer of the former Metals Branch Council which preceded The Metallurgical Society. Above, R. W. Shearman and W. R. Hibbard, Jr., Secretary and President, respectively, of The Metallurgical Society, chat with AIME Field Secretary R. E. O'Brien.

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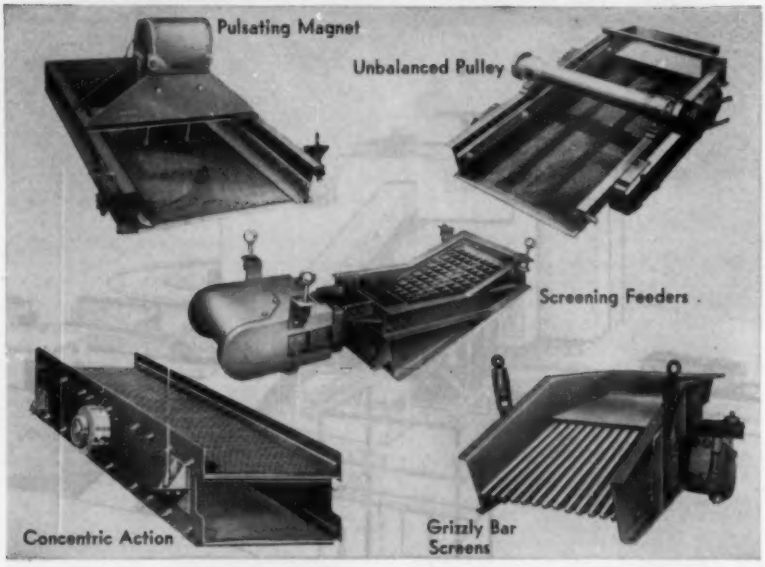

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Missouri Symposium

(Continued from page 1193)

Bruzewski, George B. Clark, Joseph J. Yancik, and K. M. Kohler. George J. Dole will discuss the *Application of New Research Data in Blasting With Ammonium Nitrate Explosives.* The final paper of the symposium will present the *Properties and Performance of AN Blasting Agents.* The authors of this paper are R. D. Doddorff, R. Simmons, and R. W. Lawrence.

The chairman responsible for the symposium is George B. Clarke. He and his committee members have organized a comprehensive technical program covering new developments in the explosives field.

Coal Division News

(Continued from page 1197)

the leaders and others responsible for the project were highly gratified by the results. M. D. Cooper, director of mining engineering education of the National Coal Assn., who accompanied the boys on their trip to Cadiz, Ohio, to visit the operations of the Hanna Coal Co., had this to say about the project: "As a means of giving these high school students a birdseye view of a part of the coal industry and the opportunity to visit a university where instruction in coal mining is very thorough, I am sure that the trip was well worthwhile. Probably some of the students will be influenced to study mining engineering and obtain employment in the coal industry. The others will at least have a good understanding of the operation of modern coal mines and they will have a sympathetic interest in the coal industry. Therefore, you may feel that the efforts made by you and your committee were valuable."

What has been done with this project for the mining engineering field can likewise be accomplished for other aspects of mining as well as for the fields of metallurgical and petroleum engineering. With the cooperation of industry and schools, it can become a vital program on a national scale, as WAAIME hopes.

During the tour of the Grant Town plant of Eastern Gas & Fuel, some of the boys participating inspect a control panel.

Members: Help a Nonmember fill out this handy application—

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FOR OFFICE USE

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Credit application to: _____ (Member's Name)

I hereby apply for { admission / change of status / reinstatement } to the grade of _____ (Member; Associate Member; Junior Member) in the SOCIETY OF MINING ENGINEERS OF AIME

Name (Please print) _____ Last Name _____ First _____ Middle

Company _____

Your Business Address Where Employed _____

Please State Nature of Company's Business: _____

Professional Title _____ Present Position _____

Address where you desire Society mail to be sent (If not your business address) _____

Born (exact date) _____ at _____ Citizen of _____

ENDORSEMENTS . . . Applications must be endorsed by three AIME Members, Associate Members, or Junior Members who know the applicant personally. Endorser should fill in the spaces to the right of his signature. (Membership in certain other technical societies that have equally high standards of membership may be used in lieu of two endorsers if necessary.)
If you wish the Society to secure the necessary signatures, please list the names of four members who are familiar with your profesional qualifications.

(Print here)	Signature	How long have you known the applicant?	Has he been employed under your supervision?	Grade for which you believe him qualified
Name _____				
Company _____				
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Company _____				
Name _____				
Company _____				
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Company _____				

EDUCATION Give specific degrees and exact dates. A technical education is not requisite for membership.

	Dates	Degree and Date	Major Subject Or Engineering Field	Minor Subject
Preparatory School _____				
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Graduate Work _____				

If you attended college but did not complete, indicate course taken and number of years completed _____

Be Sure to Fill in Both Sides—Turn the Page

PRIMARY INTEREST FIELDS Please indicate the technical fields in which you are most interested. Mark 1, 2, and 3 in order of preference.

- ☐ Open Pit Mining (Ore)
- ☐ Underground Mining (Ore)
- ☐ Geology
- ☐ Geophysics
- ☐ Geochemistry
- ☐ Coal
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  - ☐ Preparation
  - ☐ Utilization
- ☐ Industrial Minerals
- ☐ Minerals Beneficiation
- ☐ Education
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RECORD OF EXPERIENCE

Please list in chronological order a complete record of your employment. Be explicit as to dates, your duties, nature of the work, and the extent to which you were in responsible charge of your own work or of the work of others. Include all positions held, whether or not they are related to the mineral industry. If additional space is needed, use separate sheet of the same size.

Dates From	Dates To	Title of Position, Name of Company Description of your work	Total Time	Time you were in responsible charge*	Name, Title and address of your immediate superior, or of other person familiar with your work

I agree, if elected, to accept election, pay the necessary fees, and to abide by the Constitution and Bylaws.

Do you desire to pay the Entrance Fee in four installments of $5.00 each

Yes _____ No _____

_____
Signature

Date _____

*Responsible for the conduct of technical or engineering work. Employment as a teacher may be so considered responsible for conduct of work.

Around the Sections

The members of the Philippine Section at a meeting in Baguio City, listening to A. J. Farretta give an after-dinner talk.

• New officers of the **Southern Sierra Subsection** for 1958-1959 are Lloyd H. Rockdale, chairman; John E. Martinson, vice chairman; and James D. Mulryan, secretary-treasurer.

• The **Philippine Section** holds four meetings a year, two in Baguio City and two in Manila, with an impressive international attendance at all sessions. The last meeting was held July 26 at the Baguio Country Club and featured cocktails and a roast beef dinner, as well as two interesting talks. A. J. Farretta spoke on *The Acupan Mine Fire*, describing the outbreak of fire and the methods of combating it. L. A. Dahners spoke on *Sand Filling at Lepanto* before Joe Pickard, chairman, brought the members up to date on Section business, and they all adjourned for more sociality.

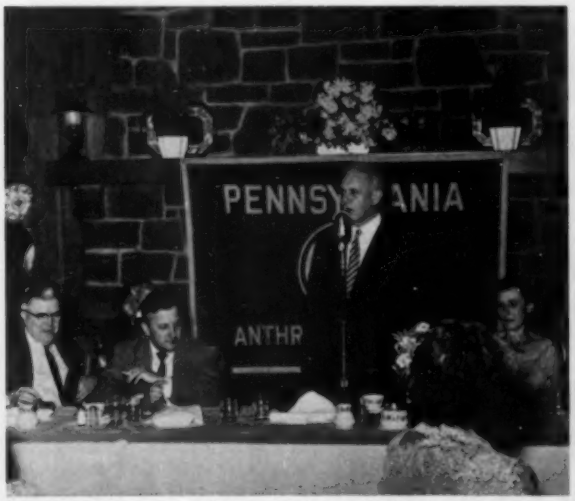
• The **Uranium Section** had an impromptu picnic on August 3 to which families brought their own lunches and drinks were waiting gratis.

• The **Eastern North Carolina Subsection,** Southeast Section, held a special meeting at Hotel Kitty at Wrightsville Beach on July 19. A business session took place in the morning before luncheon. Chairman A. M. Szynklewski announced that the group will sponsor a student paper competition open to undergraduates of Duke University, the University of North Carolina, and North Carolina State College. A prize of $100 will be awarded to the best paper on the earth sciences submitted before Jan. 1, 1959.

• The **Minerals Beneficiation Subsection** of the Minnesota Section met June 11, and the Mesabi Country Club, Hibbing, was the site for the evening conference that ended a highly successful season. S. E. Erickson, director of beneficiation for the M. A. Hanna Co., presented a *Review of the Competitive Position of Low Grade Mesabi Iron Ores.* A lively discussion followed the talk and pointed out that the future of the western Mesabi Range will depend upon a lower tax burden, lower royalty fees, and high productivity.

Newly elected officers for the fall

(Continued on next page)



Attentive listeners at the Pennsylvania-Anthracite Section summer meeting hear AIME President Augustus B. Kinzel give an address. Left to right are Joseph Kennedy, Harold B. Wickey, Augustus B. Kinzel, and Mrs. Kinzel. A group shot of the notables on the lawn of Split Rock Lodge are (clockwise from Mr. Kinzel) Floyd Sanders, David Mitchel, John Griffiths, John Marshall, Ernest Kirkendall, and Walter Petzold, the Section chairman. The following officers were elected for the coming year: Harold B. Wickey, Glen Alden Corp., as chairman; Floyd S. Sanders, Goodman Mfg. Co., as secretary-treasurer; and members of the executive committee, D. E. Ingersol, U. S. Bureau of Mines; D. M. Blackburn, Hendrick Mfg. Co; James Tedesco, Pagnottii Interest; John C. McCartney, consulting engineer; and Charles Brown, Reading Anthracite Co. Members and new officers enjoyed the party.

and winter sessions are Leon D. Keller, chairman; Fred H. Bunge, vice chairman; and R. C. Ferguson, secretary-treasurer.

• The **Colorado MBD Subsection** annual meeting was held on May 24 at the Broadmoor Hotel, Colorado Springs. J. R. Purdy was chairman of the business meeting and handled the election of officers. The new chairman is F. T. Davis; Ralph C. Toerper is vice chairman; and the secretary-treasurer is W. C. Mason. Chairmen of the various committees were appointed as follows: Nominating, A. G. Setter; Program, C. V. Johnson; Membership, E. J. Garbella; and Technical Program, S. P. Warren.

Another important development of the business meeting was the resolution to give funds to the Colorado School of Mines Loan Fund. This donation will provide money for students preparing for service in the profession. The loans will be repaid so that the contribution will not be exhausted. The Subsection gave $250 to help the school fund.

Preparations for next year's meeting are already beginning, with the chairman of the Technical Papers Committee, S. Power Warren, seeking suggestions for topics to be considered and MBD activities most important for consideration. The meeting will be held on April 18, again at the Broadmoor Hotel. Any suggestions should be sent to Mr. Warren.

These smiling engineers and plucky wives are on a caravan from Ouray to Lake City to Silverton, Colo., studying the geology on the way. This was the August 2 field trip of the Colorado Plateau Section. A few of the notables in the picture are the chairman, George Setter; the secretary-treasurer, T. S. Ary; the program chairman, Gilman C. Ritter; William Hasler, first vice chairman; Mrs. Kay Setter, chairman of the Women's Auxiliary; and Henry R. Wardwell. Mark Shipman snapped the cheerful group on Engineer Mountain before they went through Cinnamon Pass to Silverton for dinner.

• The **Colorado Plateau Section** enjoyed interesting activities during the summer with plans that included the whole family. On June 21 they had a meeting at the Beaumont Hotel in Ouray with special arrangements to take care of the small fry. Stanley D. Michaelson, President of SME, discussed plans for the new engineering building. Papers were presented at the afternoon session by Ray Roebuck and John Jett on *Geology of the Aneth Oil Field and Driving Raises by Automatic Hoists;* and Richard Kennedy showed slides of the *South African Uranium Industry.* After the buffet dinner the party continued in the ballroom until morning.

• During the summer months when few meetings are scheduled, the family-style picnics sponsored by many of the western Local Sections have helped the members get better acquainted in friendly, casual surroundings. Many of the Sections in the Colorado, New Mexico, Utah, Nevada, and nearby areas do not hold meetings in June, July, and August.

• The **Adirondack Section** was back in the Gouverneur area for their third meeting of the 1958 season. Some members visited the Balmat mill of the St. Joseph Lead Co. and others toured the Popple Hill mill, International Talc Co. At the dinner that evening, Robert Lewis described his life in Ethiopia where he spent six years helping to found a school of engineering which has made gratifying progress.

The July meeting began at the Victoria Museum in Ottawa on Saturday, July 26, and proceeded by a caravan of cars to Wakefield, Quebec, to the brucite operations of the Aluminum Co. of Canada. Following the open pit and mill tours, the men joined their wives in Gatineau Park for a cook-out. Later there was dancing at the Lord Elgin Hotel in Ottawa.

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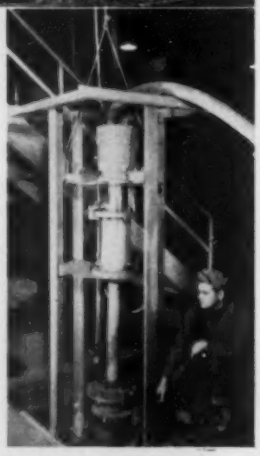

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Personals

Frank A. Burns has been appointed superintendent of the Crucible Steel Co. of America's coal mine in Crucible, Pa. He has served in various positions since he came to Crucible in 1953.

Paul H. Knowles has been made chief of U. S. Atomic Energy Commission in Chile, Div. of Raw Materials, on a two-year assignment in cooperation with the Chilean government to further their program for the investigation and uses of radioactive minerals. He had been assistant chief at Albuquerque, N. M.

Raymond E. Byler, former business manager for the Western Div. of Arthur D. Little Inc., has been appointed manager of research and development by the Western Machinery Co., San Francisco.

F. A. BURNS

R. E. BYLER

P. H. KNOWLES

P. KLEMPNER

David Jones, chief of the Army Engineers Mining Branch recently received a $200 sustained superior performance award for his work involving evaluation of all mineral properties involved in land transactions for the Army, Air Force, and the Atomic Energy Commission in six western states.

Fred Jensen has been appointed deputy state mine inspector for northern Arizona mining districts.

R. B. HOY

I. G. IRVING

Robert B. Hoy is now assistant to the chairman of the Earth Sciences Dept. of the Stanford Research Inst., Menlo Park, Calif. He was formerly chief geologist of the northeastern U. S. for The New Jersey Zinc Co.

I. G. Irving has moved to Seattle, following the shutdown of the Norwich manganese mine at Butte, Mont. He had been co-manager of the mine and now is engaged in mining geologic consulting work, and he is associated with Investment Exchange in Seattle.

Paul Klempner has been appointed progress engineer at the headquarters in London of the National Coal Board which controls Britain's coal mining industry. He will be part of the National Plan to increase production by dealing with colliery reconstruction ranging from reorganization of old mines to the establishment of new sinkings and coal preparation plants.

Paul Jasberg, until recently labora-

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PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company

Former Title ..... Length of Time There

New Company

New Title ..... Date of Change

Any recent activity that would be of interest to members:

personals

continued

tory supervisor for the U. S. Metals Refining Co., Wakefield, Mich., has resigned to accept a position with the White Pine Copper Co., White Pine, Mich.

Raoul Choate has become an instructor in geology at the University of Idaho, located in Moscow, Idaho.

P. William Bakarian has been appointed president and general manager of R-N Corp., owned equally by National Lead Co. and Republic Steel Corp. **John S. Breitenstein** and **Rollin P. Smith** have been named vice presidents of the organization, the former in charge of administration, the latter in charge of engineering. Mr. Bakarian succeeds **Alex Stewart,** who has retired. Mr. Stewart had been director of research for National Lead Co.

Top management changes in Reserve Mining Co. have been announced. **W. M. Kelley,** who has been president, retired from active business but will continue as a member of the board. **Robert J. Linney,** formerly vice president in charge of operations, was elected vice president and a member of the executive committee. The position of chairman of the Reserve board has been abolished and an official of Republic Steel Corp. and of Armco Steel Corp. will alternate each year as president of Reserve. **C. M. White,** chairman of the board of Republic, will serve as president of Reserve for the ensuing year. Another member of the executive committee is **Ralph L. Gray,** president of Armco.

At the Annual Meeting of ASTM in Boston, June 22 to 27, retiring president Richard T. Kropf presented Edgar Marburg Lecture certificate to E. W. Pehrson, 1949 AIME Mineral Economics chairman (center). Robert J. Painter, ASTM executive secretary (right) witnesses the ceremony.

Jess Larson, former head of General Services Administration, Washington, D. C., was elected president of the Uranium Inst. of America to succeed Patrick Hurley, who has retired. Mr. Larsen has handled the government's stockpiling of strategic materials as head of GSA.

Charles E. Chapin is now a geologist for the Lucky Mc Uranium Corp. in Riverton, Wyo. He had been employed as geologist by the J. M. Huber Corp. for the last three years.

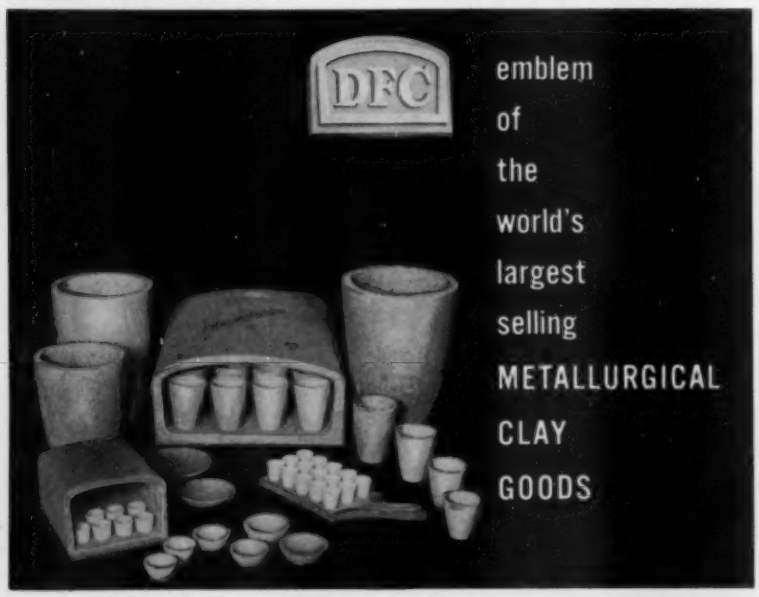
Leo C. Bailey, manager of the Mountain States Office of the Stanford Research Inst., has become industrial economist, long range company planning group, in Menlo Park, Calif. He was in Europe for most of the summer doing research on long range planning problems for large manufacturers of mining equipment.

H. Danforth Starr has been elected a director of the Central and South West Corp., public utility holding company. He is vice president, treasurer, and a director of Cerro de Pasco Corp.

W. M. KELLEY

R. J. LINNEY

Three executive changes have taken place at Noranda Mines Ltd., Toronto. **J. N. Anderson** is in charge of the firm's smelting operations at Toronto; **G. C. McKerrow** succeeds Mr. Anderson as smelter superintendent at Noranda, Que.; and **R. L. Johnston** succeeds Mr. McKerrow as superintendent of the Gaspe Copper Mines smelter at Murdochville, Que.



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J. H. Moses, chief geologist, and **Wilson D. Michell,** assistant chief geologist, are now at the Executive Offices of Reynolds Metals Co. in Richmond, Va.

John P. O'Keefe, division comptroller of Kennecott Copper Corp., Utah Copper Div., has been named to a committee for the study of Utah unemployment and compensation benefits.

Kennecott recently appointed **D. J. Reed, Jr.** as electrical design engineer and **H. H. Pick** as process design engineer of the Western Mining Divs.

Oscar A. Glaeser, vice president and general manager of western operations, U. S. Smelting, Refining & Mining Co., was elected president of the Salt Lake City Chamber of Commerce.

Fred N. Earll has been named acting head of the department of geology at Montana School of Mines and has been promoted to associate professor.

George E. Stringfellow, vice president of the Thomas A. Edison Industries of McGraw-Edison, West Orange, N. J., is the new imperial potentate of the nation's 800,000 Shriners.

John E. Husted left Battelle Memorial Inst. in November, did some consulting work for Battelle and industry, and taught geology and geography at Capital University, Columbus, Ohio. Now he is a mineral economist in the Industrial Development Branch, Engineering Experiment Station, Georgia Inst. of Technology.

E. E. THURLOW

W. E. HEINRICHS, JR.

Ernest E. Thurlow has returned to private industry after ten years with the Atomic Energy Commission in the Div. of Raw Materials. He had charge of the AEC exploration program in many parts of the west. Now he is chief geologist for Marcona Mining Co. in San Juan, Peru.

Walter E. Heinrichs, Jr., who had been general manager of Minerals Exploration Co. in Tucson, Ariz., now has formed the Heinrichs Geoexploration Co., offering mining and engineering geophysical equipment, interpretation, and services. A continuous recording mobile magnetometer is available.

Bert S. Butler, dean of American economic geologists and former head of the University of Arizona geology department, has been honored by the dedication of a guide book to the field trips of the 55th annual meeting of the Cordilleran section of the Geological Soc. of America.

Gerald Liporetz formerly a student at Michigan School of Technology, is employed as a metallurgical engineer for the M. A. Hanna Co., Hibbing, Minn.

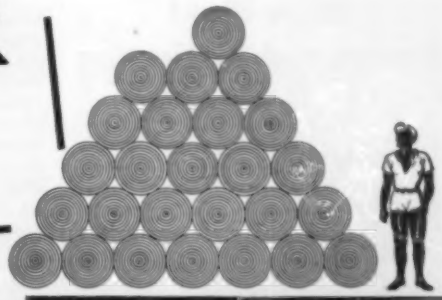
W. A. Blomstran, chief mining engineer for the Mining District of Republic Steel Corp., succeeds **Francis J. Myers** as manager of the Port Henry, N. Y., branch. Mr. Myers has retired.

Travis P. Lane has accepted a position with the Arizona Dept. of Mineral Resources as a field engineer. For the past three years he has been employed by the U. S. Atomic Energy Commission in Grand Junction, Colo. His headquarters are now in Phoenix, Ariz.

Carl H. Cotterill has been named executive assistant for American Zinc, Lead and Smelting Co. in the executive department. He had been plant and process investigator in the St. Louis office.

Edward P. Kyburz is on leave from American Smelting and Refining Co.

Over 5 tons of LINATEX combat abrasion on yet another Tin Dredge



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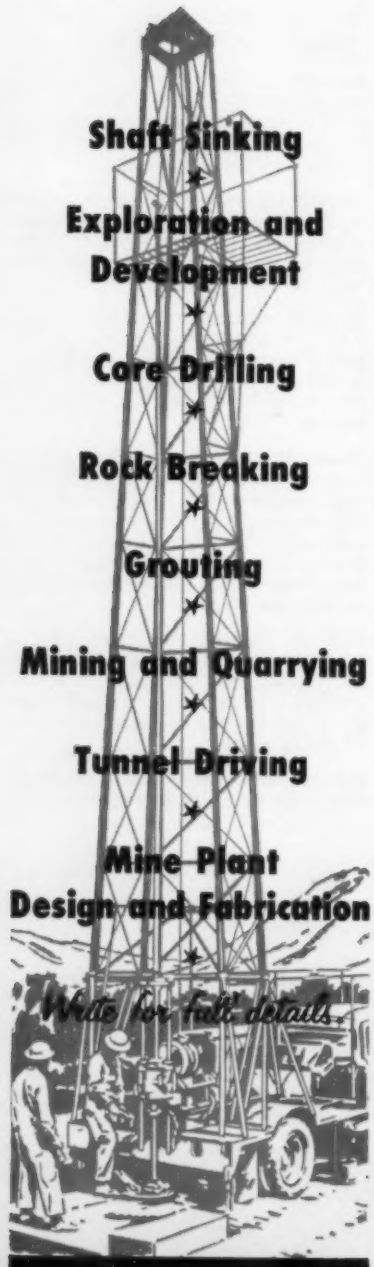

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personals

continued

to attend the College of Mines, University of Arizona, under a U. S. Bureau of Mines fellowship.

Brian P. Canning, assistant metallurgist for American Smelting & Refining Co., is now employed by the Andes Copper Corp. in Colville, Wash. In November he will go to Chile.

V. C. Kelley, professor of geology at the University of New Mexico and a director of the New Mexico Mining Assn., is returning to the University after five months as visiting professor of structural geology at Columbia University.

The board of directors of Lake Shore Inc. announced recent elections to fill the vacancies left by the death of **F. A. Flodin. B. W. Reeve** will succeed Mr. Flodin in the office of president. **Frederic Sammond** will fill the vacancy on the executive committee. A new vice president of the firm is **R. S. Shepard,** manager of Lake Shore's operations in Minnesota. Mrs. Flodin has been elected to the board of directors.

The Council of the Institute of Mining and Metallurgy have announced awards to **Maurice A. E. Mawby,** who won Honorary Membership of the Institution for his valuable services to the mining industry in Australia; and to **John K. Almond** who won the Arthur Claudet Student's Prize for his part authorship of the paper entitled *Pulp Density Measurement with Ultrasonics.*

J. R. Ruark, Jr., formerly senior principal engineer for National Lead Co., now is employed by the U. S. Borax & Chemical Corp. as a process engineer in Boran, Calif.

C. Tsoutrellis has left the Royal School of Mines in London after a one-year post-graduate course in mineral exploration to become a mining engineer in Athens, Greece, for the Hellenic Mining Co. Ltd.

George Remarcke has been promoted to mine foreman for the M. A. Hanna Co. in Iron River, Mich.

E. L. Spencer is now located at Lovelock, Nev., as plant superintendent for Eagle Picher Co., Insulation Div., at its new diatomaceous earth processing plant. Formerly he was assistant pit superintendent for Consolidated Coppermines Corp., Kimberly, Nev.

S. Power Warren has resigned from Ball Associates and is available for private consulting work at his address 1400 Pierce St., Lakewood, Denver 15, Colo.

Edward VonMoss has moved to Portsmouth, Ohio, where he is mine foreman for Fenix & Scisson Co. He had been general superintendent for the Anderson Developing Co. in Oklahoma, but has changed from metal mining to mining construction.

William G. Piper, formerly mining planning specialist for General Electric Co., is now sales technical engineer for Bucyrus Erie Co., Drill Div., in Richmond, Ind.

Gabor Dessau has completed his two-year assignment with the Technion, Israel Inst. of Technology in Haifa, where he had been sent by UNESCO to establish a Mineral Engineering Dept. Now he is back in Italy and is "Charge de cours" in mineral deposits at the Geological Inst. of the University of Pisa.

Thomas J. Ponesse is employed by the Canadian Chemical Co. Ltd. as a commercial production representative in Ville Lemoyne, Que.

William R. Moliken has been promoted to utility foreman for Inland Steel Co. He had been a supervisor trainee. He is now located in Steger, Ill.

J. C. Ferrell, formerly a student at the North Carolina State College, is a geologist for the Soil Conservation Service in Salisbury, N. C.

Harmon C. Ray special field engineer, has left Island Creek Coal Sales Co. and is working for the Monogahela & Ohio Coal Co. Inc. in Cleveland.

William B. Williams has been discharged from the service and is again in the mining business for The New Jersey Zinc Co., Empire Zinc Div., in Gilman, Colo.

Thomas R. Fuller graduated from the Industrial Management Graduate School of the Massachusetts Inst. of Technology and is employed in the Utah Copper Div. of Kennecott Copper Corp. in Salt Lake City.

Everett L. Joppa, general manager of the Lake Superior iron mining division of Pickands Mather & Co., has returned from a trip to Russia as a member of an American delegation of iron ore mining executives participating in an exchange agreement between the two countries.

Armine F. Banfield, who has served for eight years as an associate in Behre Dolbear & Co., was admitted to partnership in the firm. Dr. Banfield is at present in Iran on a professional mission.

A. Azizuddin has been made inspector of mines for the Government of the Federation of Malaya. He had been a junior engineer for Malayan Tin Dredging Ltd.

Obituaries

William Townley MacDonald

An Appreciation By
Herb Rose

Billie MacDonald, AIME member since 1901, has gone on his last Trip. Those of us who knew him intimately find it hard to believe, for his was a way of life, and kindly placidity was so much a part of him, that he should have lived forever. To us, it seemed certain he would.

Born in Denver, he naturally turned to mining as a profession. Losing his father at an early age, he gained the wherewithal for a college education from a cyanide mill in Mexico. There he was superintendent, solution man, precipitation man, pumpman, assayer, metallurgical accountant, night watchman, and day watchman—all at the same time. This allowed him enough leisure to become fluent in Spanish within the year. With this experience, it was a small further step to win his degree at Columbia in 1908, this time using his spare moments to serve as president of his class, AIME student chapter, and Tau Beta Pi.

On graduation he became one of *Jackling's boys*, starting at Magna and later becoming mill superintendent at Hurley and at Hayden. Typically, his Arizona spare time went into serving as Grand Master of the Masonic order in that state.

His early love for ore dressing stood him in good stead. Moving over to Phelps Dodge in 1921, he became mill superintendent at Nacozari. There he succeeded in the first of two achievements that must necessarily be recorded prominently in the forthcoming AIME volume on the *History of Flotation*. This was the first recorded commercial separation of copper and iron minerals by selective flotation. That separation is so commonplace today that it seems hardly worth mentioning, but the entire profession had failed in 15 years of trying, until Billie came along. He did it the hard way, too, because coal tar was the only collector we had in those days.

In the meantime, International Nickel Co. of Canada had been searching for a man to take charge of their concentrator, then being planned at Copper Cliff and which had become a necessity upon discovery of the fabulous Frood mine in 1929. That was going to take some pioneering, too, for nickel flotation was just not in the books of that day and selective flotation between copper and nickel minerals was no more than a gleam in the eye of Robert Stanley, the then president of Inco. WTM was chosen. The new mill sarted up in June 1930. Shakedown operations lasted through August. Then came the selective campaign out in the wild blue yonder. September . . . no luck. October . . . mostly the same but with a few faint rays of hope, though the operators on the pump floor had to change from knee boots to hip boots. Then Mr. Stanley came up from New York and laid it on the line: "I am a very patient man but just because this thing has never been done before is no sign it can't be. I give you until December 1 to get 'er going on a selective basis."

Well, on Nov. 29, Billie got 'er going on a selective basis and she has been going that way ever since. Her capacity has risen from 8,000 tpd to 30,000 and she has spawned two other Inco concentrators whose combined capacity equals that of the old lady.

When Billie graduated from Columbia in 1908 and married Madge Janney, they made a compact that they would use their spare time to design an outstanding home exactly to their liking in a location of their own choosing, and retire to it at age 50. Billie met the schedule, right on the nose, and the location was a high overlook at La Jolla. There, besides learning to play two

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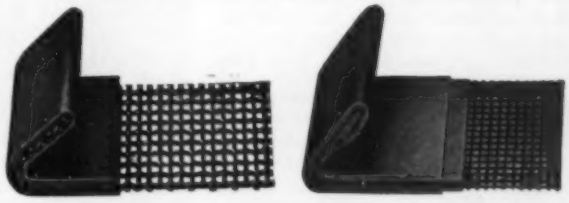

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musical instruments and also becoming a pillar of the Explorers Club, he devoted much time to his home movies, in which he was a superb artist. It is typical of the man that this past Grand Master of the Masons should win unbounded gratitude of the Franciscan fathers by preparing a documentary film on the old missions of California and Mexico, for which he would accept no remuneration, and which he exhibited widely wherever and whenever they wished.

In La Jolla, on July 9, Billie MacDonald passed to his reward. Those of us who worked with him through the years at Nacozari and Copper Cliff are sure it will be a great and deserved one. How we would love to see his movies of the Pearly Gates and the Golden Streets, and enjoy once again his huge chuckles (and priceless asides to St. Peter) as he runs them!

Oliver Bowles

An Appreciation By
Oliver C. Ralston

Oliver Bowles (Member 1914), born in the northern wilds of Ontario, Jan. 10, 1877, quite naturally took an interest in minerals of economic importance. His first professional enthusiasm was in quarrying, as the result of influence by a professor at the University of Toronto whence he graduated in 1907. Also quite naturally, he married soon thereafter. He was never a robust man and his earlier days were dubious and his longevity threatened.

A career in quarrying in the United States appeared more promising and he moved first to the University of Michigan where he was employed as an instructor and after two years moved to the University of Minnesota for another two years. When U. S. citizenship had been established, he was appointed in the U. S. Bureau of Mines, Apr. 25, 1914, with the title of quarry technologist. He remained in the Bureau for a long honorable career.

When a man is employed by USBM, he has an opportunity to diversify his interest. There is also the chance to *learn more and more about less and less* and thus become an expert on one mineral commodity or one kind of operation. Bowles expanded and began to learn more and more about more and more. Reflecting his broader horizon, his title was changed in 1918 to mineral technologist. When USBM established a nonmetallic minerals experiment station at New Brunswick, N. J., Dr. Bowles was detailed there as superintendent on July 21, 1923.

Needless to say, during his years at New Brunswick, quarrying was not forgotten. The wire saw for sawing stone was attracting attention abroad and an investigation by part of the New Brunswick staff was carried on, chiefly in New England quarries. It showed that the saw cheapened the cutting of sound stone blocks in the quarries, their slicing into shapes, and saved a great deal of waste. Studies on the physical chemistry of gypsum and anhydrite constituted another investigation which in about ten years expanded into the explanation of the action of gypsum in retarding the set of portland cement.

Asbestos, mined in both Canada and the U. S., was a commodity of consuming interest to Bowles for all of his life and the list of his publications on the subject is impressive. The annual reviews on various other nonmetallic minerals which he prepared for USBM, AIME, and the technical press were always in demand. The reliance of industry on such authoritative reviews is great. As chief of the division of nonmetallic mineral economics (we ignore details of promotions herein), a row of offices was filled as his operations expanded and more helpers employed. The number of visitors from interested mineral industries increased and all left with gratitude to the person who had given self-effacing but efficient service.

When age 70 is reached a sacred cow is involved and a civil servant *must* be retired, no matter what may be the popular demand for his services. Yes, Bowles retired in July 1947, and was decorated with the Distinguished Service (Gold) Medal of the Interior Dept. Actually, the department honored itself thereby. Fortunately, a retiree can be reemployed for special duties as a technologist or a consultant. After an appropriate period (about one year) as an annuitant, he was reappointed as mineral technologist with additional freedom to indulge in industrial consultation.

Meeting these specifications, Bowles put in another ten years mainly on special assignments and was no longer burdened with the paper work of an executive. He would have been very unhappy to live the life of a *worn out* retiree. *He never wore out*, and the infrequence of sick leave was impressive. Health so often comes to those who are happy with their work. One interesting job after another was executed just in time to have another loom. Who would not be enlivened? Who would not stay young? All this was a richly deserved reward for many years of faithful service.

An impressive list of his membership in technical and scientific organizations should be recorded. In addition to membership in AIME, Dr. Bowles was a charter member of the Mineralogical Soc. of America; The Soc. of Economic Geologists; honorary member of the British Inst. of Quarrying; The Soc. of Sigma Xi, and the famous Cosmos Club of Washington. He was awarded a Ph.D. degree by George Washington University in 1922, both on credits earned and honors deserved.

If Oliver Bowles was a workhorse, he was one of a team formed when he married Eva Honey Workman, of Ottawa, in April 1908. Their 50th wedding anniversary was celebrated this year. They had two sons: Edgar Oliver Bowles and William George Bowles; and Dr. Bowles also left a brother, Herbert Edgar Bowles of Welland, Ont. Mrs. Bowles has perhaps been more prominent than her husband in AIME. In WAAIME, she was more than a tireless worker, both in the Washington Section and finally as head of the National organization. The record of this pair in AIME is challenging.

Oliver Bowles was an equally assiduous church worker, widely known in respect for his convictions. His calm, quiet, and kindly manner on all subjects, sacred or secular, made it unnecessary to fight for his convictions or objectives because he gained them without bickering. His sincerity demanded respect.

Bowles' death was completely like his life. On that day, Friday, Aug. 1, 1958, he turned up at the office with a completed report that involved a recent trip, saw his fellow workers, and was as chipper as ever. When he left he gathered his family to drive to their summer home in Virginia. Arriving there, he suggested a nap as a refresher before preparing for the evening. Dr. Bowles,

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Eva, and son Edgar did so. Two of them later awoke. Bowles did not—he was in his last sleep.

Necrology

Date Elected	Name	Date of Death
1938	Milan A. Arthur	July 29, 1958
1900	Samuel Barker, Jr. Legion of Honor	July 20, 1958
1953	Ernest A. Brown	May 15, 1958
1940	Hilmar R. Hagen	July 16, 1958
1914	Ott F. Heizer	May 19, 1958
1928	Edward H. Hoag	June 1958
1929	Ernest Klepetko	June 27, 1958
1901	William T. MacDonald Legion of Honor	Aug. 9, 1958
1954	Frederick A. McCoy	Aug. 27, 1958
1947	Alexander A. McLeod	July 2, 1958
1892	George A. Packard Legion of Honor	July 18, 1958
1948	Carl K. Stewart	June 27, 1958
1955	R. S. Stewart	Unknown
1941	Erwin Vogelsang	Sept. 2, 1958
1905	C. Y. Wang Legion of Honor	Aug. 30, 1958
1947	S. T. Yuster	Unknown

Membership

Proposed for Membership
Society of Mining Engineers of AIME

Total AIME membership on Sept. 30, 1958, was 30,654; in addition 3,131 Student Members were enrolled.

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E. H. Crabtree, Jr., Chairman; Frank Ayer, Jack Bonardi, Edward G. Fox, J. A. Hagy, F. W. McQuiston, Jr., Pauline Moyd, A. D. Rood, L. P. Warriner.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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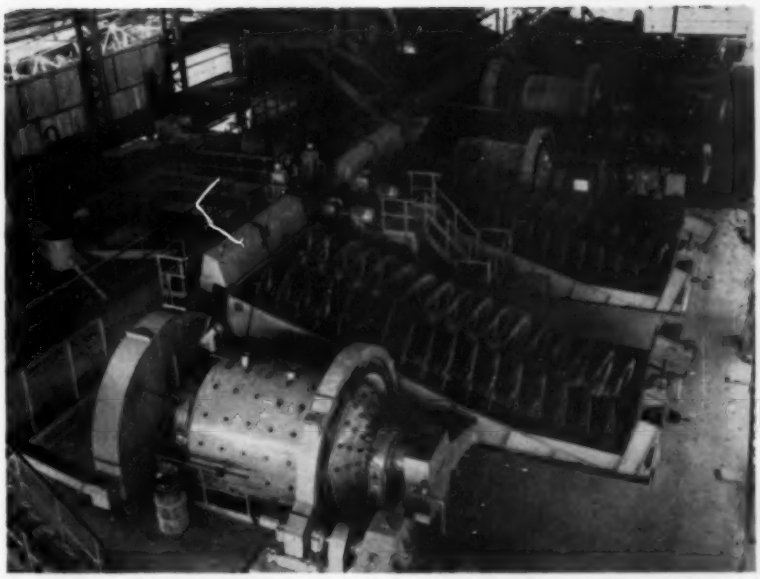

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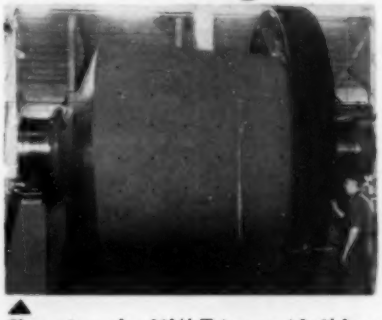

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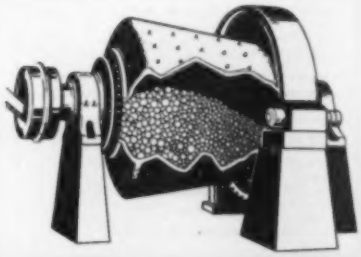

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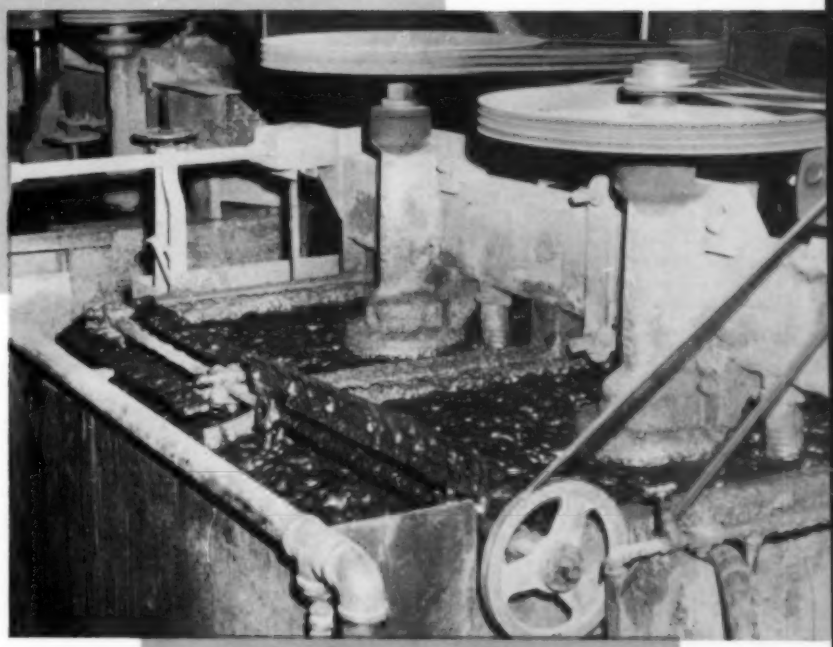

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